MACHINERY.

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WHAT A MACHINE DESIGNER SHOULD KNOW ABOUT SPRINGS.

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SPRINGS are used so extensively in the construction of machines that a knowledge of the principles upon which their action depend will often be needful, and I shall endeavor here to present the matter in such form that it may be understood by all.

Although made in a great variety of shapes, the working and efficiency of any spring can be readily understood and investigated from a few fundamental principles, which determine the resistance to bending or twisting and the deflection of elastic bodies. Springs are generally made of steel or brass, and when under tension are either bent or twisted. Let us therefore first consider a flat piece of tempered cast steel of even thickness and width, firmly clamped at one end and a weight suspended at the free end, as shown in Fig. 1. The free length is a little over 12

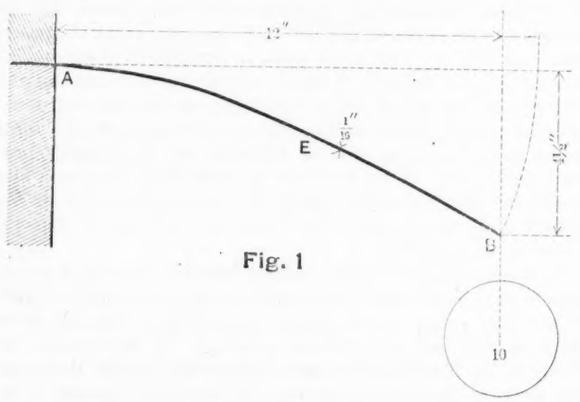


Fig. 1

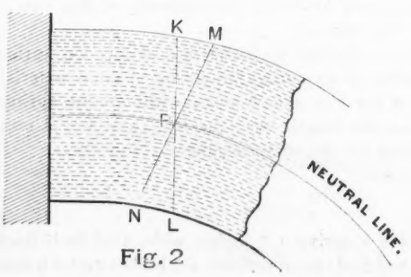


Fig. 2

inches, the width 1½ inches, the thickness 1-16 inch, and the suspended weight is 10 pounds. The deflection at the free end will be about 4½ inches, and the curvature will be as shown in the figure. If made of high carbon crucible steel, properly tempered, 10 pounds is a safe load on this spring, but it may carry considerably more before the elastic limit is reached. These facts were obtained by calculation, and I shall later explain how it is done.

It is obvious that the curvature of any part of the spring depends on the leverage or arm of bending, or rather on the "moment of bending," which is the weight multiplied by its arm of leverage. At *A* the arm is 12 inches, at *E* it is 6 inches; the moment of bending at *E* is therefore only half the moment of bending at *A;* at *B* there is no arm, and therefore no bending. Consider a small part—an element—of the curve at *A*. This element will be bent as the arc of a circle, and the radius of this arc is called the radius of curvature at *A;* any element nearer *B* will have a larger radius of curvature. At *A* the radius of curvature is about 11 inches, at *E* it is about 22 inches, and at *B* it is infinite. The curvature at any point is the reciprocal of the radius of curvature.

Considering any spring, we must first know whether it is strong enough to carry the load or will stand the work for which it is intended. The mistake is often made of using, or attempting to use, a spring which has not sufficient strength or endurance for the work it has to do, and which, consequently, gives out after being in use a short time. The spring shown in Fig. 1, being of even thickness through its entire length, is evidently weakest where it is bent most; that is, at *A*. The moment of bending at this point is $10 \times 12 = 120$, and the bending brings forth a moment of resistance or internal resisting moment in the steel equal in magnitude to the bending moment of the extraneous force, and the question to be decided is: What is the greatest fibre stress caused by this moment? Is it within the safe limit?

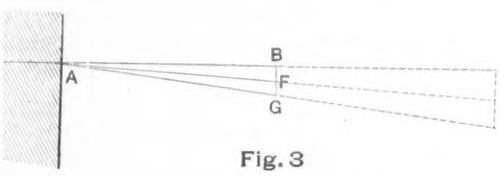


Fig. 3

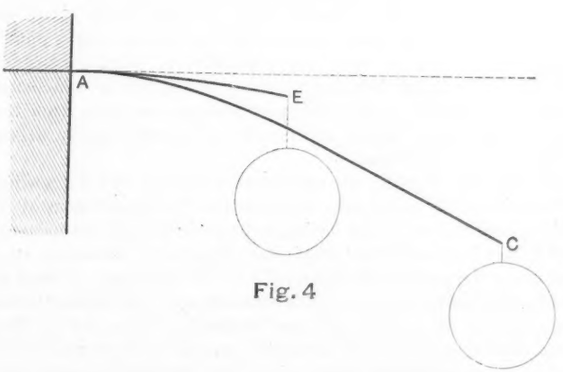


Fig. 4

Let Fig. 2 represent a small part of the spring greatly magnified and the bending greatly exaggerated, and let the dotted lines represent imaginary fibres or thin parallel strings or strips of steel. The upper half of these will be stretched, and the lower half will be compressed; but right in the center line of the thickness of the spring the fibres will neither be stretched nor compressed, and this line is therefore called the neutral line. We may consider any point in this line as a pivot for a double-armed lever to which the fibres are attached. Let *P* be the pivot and let *K L* represent the position of the lever before bending and suppose that this lever, by the bending of the spring, is thrown in the position *M N*, then *K M* represents the amount of stretching of the extreme upper fibres, and *N L* represents the compression of the extreme lower fibres, or rather of a small part of these. Steel is not fibrous, but we may call a string of molecules a fibre. All the fibres will be stretched or compressed in proportion to their distance from the neutral line, and they will therefore exert a certain resistance on the imaginary lever *M N*, and this collective resistance will exactly counterbalance the weight on the end of the spring acting on the lever *A B*, Fig. 1. The outside fibres will be stretched or compressed most, and if they are

stretched beyond a certain limit, the spring will break or receive a permanent set. If we double the thickness of the spring, it can evidently only bend half as much before the limit of fibre stress is reached; but the average distance of the fibres from pivot P will in this case be doubled—that is, the leverage of resistance will be doubled and the number of fibres will also be doubled. The total resistance to bending *at the same limit of fibre stress* will therefore be twice doubled; that is, it will be $2 \times 2 = 2^2 = 4$ times as great, or, in other words, doubling the thickness of a spring four-doubles its carrying capacity. If we had increased the thickness by one-half only, we should have $(1\frac{1}{2})^2 = 2\frac{1}{4}$ times greater strength. Generally, let T and U represent the respective thicknesses of two similar springs of same width and length; then

$$\frac{\text{carrying capacity of spring T}}{\text{carrying capacity of spring U}} = \frac{T^2}{U^2}$$

or, the carrying capacities of otherwise similar springs are as the square of their respective thicknesses. But this rule applies to bending only, and not to springs which are twisted. Now, the strength of a flat spring is in simple proportion to its width, which is obvious without demonstration, and therefore, if thickness $= t$ and width $= b$, moment of resistance for a given fibre stress $= c\,b\,t^2$, where c is a constant factor dependent on the allowable fibre stress. This factor can be found experimentally. Suppose, for instance, it is known that 10 pounds is the greatest load which the spring shown in Fig. 1 ought to carry, then in this case moment of bending $= 10 \times 12 = 120$, and moment of resistance $= c \times 1\frac{1}{2} \times (\frac{1}{16})^2 = \frac{3}{512}c$. Equating these two quantities we have $120 = \frac{3}{512}c$ or $c = 20480$. Now c being a known constant factor, we can always find the moment of resistance from the formula $c\,b\,t^2$, and this product divided by the leverage of the load gives the carrying capacity or admissible load. For instance, let the length or leverage be 10 inches, the width 1 inch and the thickness $\frac{1}{8}$ inch, then

$$\frac{20480 \times 1 \times (\frac{1}{8})^2}{10} = \frac{20480}{640} = 32 \text{ pounds} = \text{safe load}$$

on the free end of the spring. Great exactness is not necessary in such calculations, and the factor 20,500, being easier to remember, may be used instead of 20,480. If a spring is continually working, a smaller factor must be used than would be admissible if it was only occasionally in action, and a much higher factor may be used if it has only to exert a constant pressure without any bending motion. If a spring is sufficiently strong and durable under certain conditions, we may, from the formula here given, design any number of springs equally strong under similar conditions.

We will now consider the amount of deflection of a flat spring. Referring to Fig. 3, suppose there be one flexible element at A, and suppose the rest of the spring to be perfectly stiff or unelastic, which part I will call the "arm," and suppose the deflection at A will bring the arm in the position $A\,F$. If there now, instead of one flexible element, be two such elements at A, the inclination of the arm will be on line $A\,G$, and deflection $G\,B = 2\,B\,F$. For three flexible elements the deflection would be three times $B\,F$, and so on, provided the length of the arm remains the same; that is, the deflection of the arm $A\,B$ is directly proportional to the number of flexible elements at A. Now suppose we double the length of the arm, as shown in dotted line, then we also double the moment of bending, and the deflection at the end of the arm will therefore be twice doubled. Therefore, by doubling the number of elements at A and by doubling the arm, we increase the linear deflection at the free end $2 \times 2 \times 2 = 2^3 = 8$ times. In reality the arm itself is flexible, and considering it as made up of flexible elements, we may imagine the deflection at the free end made up of a series of decreasing elementary deflections corresponding to a series of flexible elements of the spring and their respective arms. Fig. 4 shows the curve of two similar springs of different lengths similarly loaded. $A\,C$ represents the curve when the length is double that of $A\,E$. Suppose we divide $A\,E$ in a number of small parts and call these elements, and divide $A\,C$ in the same number of parts, each of these will contain two elements; that is, for each element of $A\,E$ there will be two corresponding elements of $A\,C$, and the distance of any two such elements from the end of the spring will be twice the distance of the corresponding element of $A\,E$ from E. That is, the arm and the moment of bending of any two elements of $A\,C$ will be twice the arm and moment of bending of the corresponding element of $A\,E$. The deflection of spring $A\,C$ will therefore be $2 \times 2 \times 2 = 2^3 = 8$ times the deflection of spring $A\,E$. If the deflection of spring $A\,E$ is $\frac{3}{8}$ inch, the deflection of spring $A\,C$ will be $2^3 \times \frac{3}{8}$ inch $= 3$ inches. If the deflection of $A\,E$ is $1\frac{1}{4}$ inches, the deflection of $A\,C$ will be $2^3 \times 1\frac{1}{4}$ inches $=$ 10 inches, provided it is strong enough to carry the load. If spring $A\,C$ had been three times as long as $A\,E$ there would for each element of $A\,E$ be three corresponding elements of $A\,C$, and the moment of bending of any such group of elements would be three times the moment of bending of the corresponding single element of $A\,E$, and the distance of any group of three elements of $A\,C$ from C would be three times the corresponding distance on $A\,E$; we should therefore in this case have deflection at the free end of $A\,C = 3^3 = 9$ times the corresponding deflection of $A\,E$. If in this case the deflection of $A\,E$ was $\frac{1}{4}$ inch, the deflection of $A\,C$ would be $3^3 \times \frac{1}{4}$ inch $= 6\frac{3}{4}$ inches. If the length of $A\,C$ was $1\frac{1}{2}$ times the length of $A\,E$, we should have deflection of $A\,C = (1\frac{1}{2})^3 \times \frac{1}{4}$ inch $= \frac{27}{32}$ inch. Generally an increase of the length has a triple effect on the deflection at the end, which therefore becomes proportional to the third power of the length of the spring. The amount of deflection can be expressed by the formula $a\,l^3$, where l is the length and a is a factor dependent on the load, width, thickness and material of the spring. If we double the width the bending moment for each element of the width will be halved, and the deflection will consequently be half that of the narrower spring. If we double the thickness of the spring, its area of cross-section is doubled, as is also the average distance of the fibres from the neutral axis, and besides for a given curvature or deflection the outer fibres will be stretched twice as much, and will therefore offer twice the resistance (see Fig. 2). The total resisting moment if therefore increased $2 \times 2 \times 2 = 2^3 = 8$ times, or, generally, increasing the thickness of the spring has a triple effect on the moment of resistance, which therefore becomes proportional to the third power of the thickness, and the deflection will be inversely proportional to this. If, for instance, we double the thickness and double the length of a flat spring, the deflection will remain the same for the same load. The deflection will also be directly proportional to the load.

It should be observed that we have here the moment of resistance in its general sense; that is, without any restriction in regard to the fibre stress. If we impose the condition that the fibres shall be stretched to a certain extent, as in the formula for strength, the fibre stress becomes independent of the thickness, and we have therefore in that case the thickness squared in the moment of resistance, and it should be remembered that this is only in the formula for strength.

We are now able to calculate the deflection of any flat spring if we know the deflection of any other flat spring of same material. Let $f =$ deflection of the free end, $b =$ the width of the spring, $t =$ the thickness, $l =$ the length, $w =$ the load, and $k =$ a constant factor depending on the material, then

$$f = \frac{w\,l^3}{k\,b\,t^3}$$

Now suppose we have a spring $1\frac{1}{2}$ inches wide, 1-16 inch thick and 12 inches long, and find that it deflects $4\frac{1}{2}$ inches under a load of 10 pounds, then we have

$$4\frac{1}{2} = \frac{10 \cdot 12^3}{k\,(1\frac{1}{2}) \cdot (\frac{1}{16})^3}$$

from which we deduce $k = 10{,}500{,}000$.

Suppose we have a spring 1 inch wide, $\frac{1}{8}$ inch thick, 12 inches long and a load of 25 pounds on the end of it. If this spring is made of best high carbon cast steel, properly tempered, we may use the constant factor, 20,500, in the formula for carrying capacity, and have greatest permissible moment of resistance $= 20{,}500 \times (\frac{1}{8})^2 = 320.3$, and moment of bending $= 12 \times 25 = 300$. Twenty-five pounds is therefore a safe load on this spring. For $k =$ 10,500,000 we have the deflection $= 2\frac{1}{8}$ inches. A spring $\frac{1}{8}$ inch thick will carry four times as great a load as one 1-16 inch thick, but the deflection under this load will only be one-half of that of the thinner spring; or, generally, *for the same fibre stress* and same length the deflection will be inversely proportional to the thickness.

It is an easy matter to find the deflection of a spring by actual trial and then obtain the correct value of the constant k by calculation, as here explained; but the thickness of the spring must

be very carefully measured, for it will be observed that a small variation in the thickness has a great effect on the deflection, and particularly so if thin springs are used. If, for instance, the deflection of a spring 1-16 inch thick is 4 inches, then the deflection of a similar spring which is 1-100 inch thicker will only be 2 inches for the same load. The deflection may also be found if the "modulus of elasticity" of the material is known, but there are several reasons why I would not recommend this method.

The modulus of elasticity is the ratio of a direct pulling force to the extension per unit of length of a rod of 1 square inch sectional area. The extension must be within the elastic limit of the material, and is a very small quantity which can only be found by very careful measuring in a testing machine; and as it is obtained by a straight pull, it cannot furnish so trustworthy a constant for the calculation of bending deflection as that obtained by the method here proposed. If a steel bar 1 inch square and 10 inches long is stretched one-hundredth of an inch by a pull of 30,000 pounds, the modulus of elasticity is $30{,}000 \times 100 \times 10 = 30{,}000{,}000$, which is the approximately correct figure for untempered steel. For tempered cast steel it is about 42,600,000, according to Reuleaux. The tensile strength of different steels varies considerably. The strength of high carbon cast steel is greatly

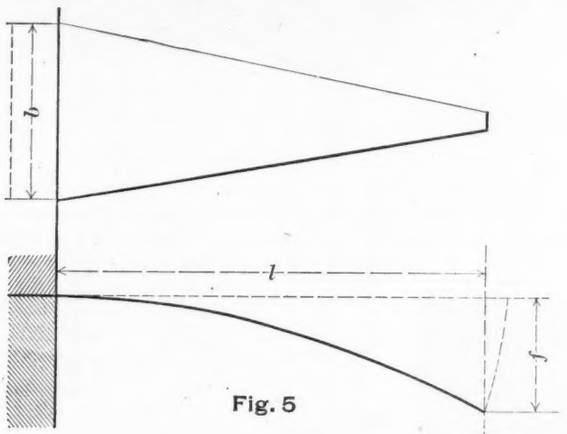


Fig. 5

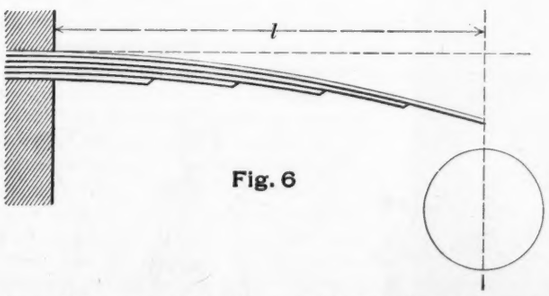


Fig. 6

increased by tempering. The so-called spring steel is probably more elastic, but less strong, and it is doubtful whether tempering changes its elasticity, while it no doubt increases the elastic limit and the tensile strength; but nothing can compare in strength with refined high carbon crucible cast steel, properly tempered. The allowable fibre stress depends to a great extent on the treatment of the steel; it may, according to Reuleaux, exceed 200,000 pounds per square inch at the elastic limit. In the formula for carrying capacity, the factor c should be one-sixth of the allowable fibre stress, and in the formula for deflection of a flat spring of even thickness and width the factor k should be one-fourth of the modulus of elasticity. The allowable fibre stress is, of course, always less than the elastic limit.

A single steel band of even thickness and width does not always make a desirable spring, for if it is made just strong enough at its base, it will be stronger than necessary at other points, and the deflection at the free end will be less than if every part of the spring was equally strong—that is, if the fibre stress was uniform through the entire length. The spring shown in Fig. 5 is of nearly correct form; it is of even thickness and the edges converge nearly to a point.

It is obvious that, in practice, the end must be made a little blunt; but suppose it was continued to a sharp point, then it will be seen that the width is, at any point of the length, proportional to the arm of leverage; the radius of curvature would therefore be the same at any point—that is, the spring would bend to the arc of a circle. The strength is the same as that of a spring with parallel sides, but the deflection at the end will be one-half greater, and in the formula for deflection the factor k becomes two-thirds of that for parallel sides. Let the triangular spring be 2 inches wide at the base, 10 inches long, 1-16 inch thick, and made of high carbon tempered cast steel, then

$$\frac{2.20500}{16^2.10} = 16 \text{ pounds}$$

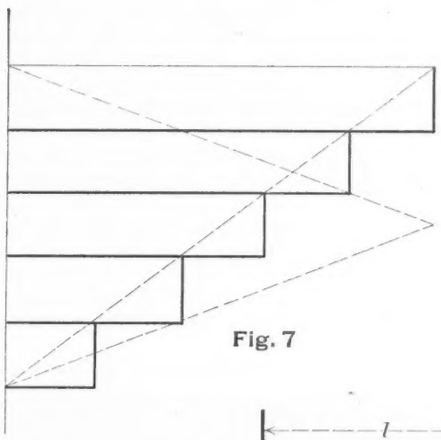


Fig. 7

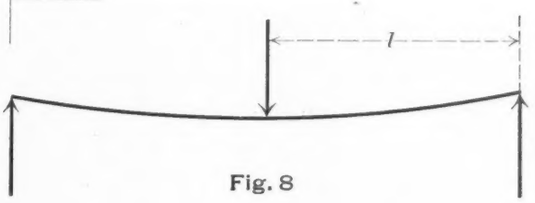


Fig. 8

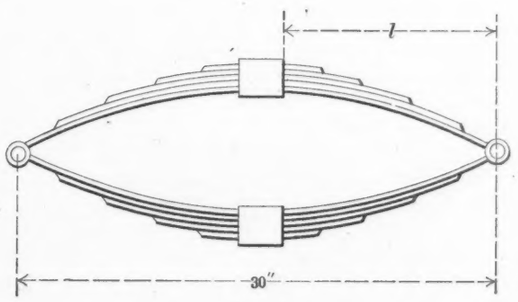


Fig. 9

is a safe load, and the deflection for this load is

$$\frac{16.10^3}{7{,}000{,}000.2} = 4\tfrac{11}{16} \text{ inch.}$$

The factor 7,000,000 is here one-sixth of the supposed modulus of elasticity. All that has been said about springs with parallel sides is also applicable to triangular springs, with the exception of the form of the curve and the factor k in the formula for deflection.

To get the most work out of a spring of given length or weight, it will often be found advantageous to use thin wide springs instead of thicker narrow ones, for it will be noticed that it is only the outside fibres which can be fully stretched or compressed, while all the others will be less useful in proportion to their distance from the neutral axis. Instead of one broad triangular spring we may use a number of parallel springs, one on top of the other, as shown in Fig. 6. Each leaf

or plate of this spring will be bent nearly to the same curve, and the deflection will be nearly equal to that of a triangular spring with a base equal to the collective width of all the leaves. Fig. 7 shows the leaves in the same plane, and the dotted lines show the approximate size of the equivalent triangular spring. Suppose there be five leaves of tempered spring steel 2 inches wide and ⅜ inch thick, and let the working length of the main leaf be 18 inches, also suppose the safe working fibre stress for this spring is 96,000 pounds per square inch, then we may, in the formula for strength, put

$$\text{factor } c = \frac{96{,}000}{6} = 16{,}000$$

and the safe moment of resistance becomes $5.2 \cdot (\frac{3}{8})^2 \cdot 16{,}000 = 22{,}500$, which divided by 18 gives 1,250 pounds as a safe working load on the end of the spring. Let the modulus of elasticity be 30,000,000, then we may in this case put $k = 5{,}000{,}000$, and the deflection equals

$$\frac{1{,}250 \cdot 18^3}{5{,}000{,}000 \cdot 10 \cdot (\frac{3}{8})^3} = 2\frac{3}{4} \text{ inch.}$$

The factor 10 in the denominator is the summation of the width of the leaves.

It should be remarked that the deflection of such springs may vary considerably from that of the supposed equivalent triangular spring, and to get fairly correct results the factor k should be obtained by actual trial, and not from the supposed modulus of elasticity.

Fig. 8 represents a steel plate supported at both ends and a load P applied at the center. The upward pressure or reaction of each support is $\frac{1}{2} P$, and it will readily be seen that the deflection of this spring must be exactly as if it had been supported at the center and loaded with $\frac{1}{2} P$ at each end; that is, the moment of bending at the center is $\frac{1}{2} P l$.

Fig. 9 represents a so-called elliptic spring, as used on railroad cars. It is made of steel plates 4 inches wide and ⅜ inch thick. The distance between centers is 30 inches, and there are five plates in each part. By courtesy of the A. French Spring Company, I am able to give the following experimental data on this spring: Light load = 2,000 pounds; maximum working load = 7,000 pounds; deflection due to an increase of 5,000 pounds = 3 inches. Comparing this case with that represented by Fig. 8, we take in account half of the ellipse only, and assuming the band to be 3 inches wide, we have $l = 13\frac{1}{2}$ inches, and moment of bending for maximum load = $13\frac{1}{2} \times 3{,}500 = 47{,}250$. Moment of resistance = $5.4 \cdot (\frac{3}{8})^2 c = \frac{81}{512} c$. These two quantities must be equal, therefore $47{,}250 = \frac{81}{512} c$ or $c = 16{,}800$. This value of c may correspond to a fibre stress of $6 \times 16{,}800 = 100{,}800$ pounds per square inch; but it would not be an absolutely safe assumption, for the theory of indirect molecular action is not yet fully substantiated by experimental data. The deflection of one-half of this spring is $1\frac{1}{2}$ inches for 5,000 pounds load; therefore,

$$1\frac{1}{2} = \frac{2{,}500 \cdot (13\frac{1}{2})^3}{k \cdot 20 \cdot (\frac{3}{8})^3}$$

that is, $k = 3{,}888{,}000$. Assuming the curve of deflection similar to that of a single triangular spring, we should have, approximately, modulus of elasticity = $6 \times 3{,}888{,}000 = 23{,}328{,}000$, but this is probably too low a figure. By using the constant factor 3,888,000 sufficiently accurate results would be obtained for similar springs of similar material.

In a subsequent number I shall continue the subject, taking up some other forms of the springs

* * *

The Patent Office official bowed politely from his place at his desk as the visitor in clothes of cleric cut and a smooth face greeted him with a subdued "Good morning, sir."

"Good morning," responded the official, with a cheerful, hundred-and-fifty-dollar-a-month manner. "Is there anything we can do for you this morning, sir?"

"I don't know, really, sir," crooned the caller, softly. "To know if you can is the object of my visit this morning, sir."

"Very well, state your case, and if we can do anything for you, you may rest assured it will be done."

The visitor cleared his throat pretty much as if he were going to deliver a sermon.

"I think," he said, slowly and with hesitation, "if I mistake not, that I saw a statement in some one of the public prints that this office would not issue a patent on Sunday. Is that true, sir?"

"Quite true. It does not."

"Why is that, sir, if I may ask?"

"It is against the rules of the office is all I know."

"Will it issue one on any other day of the seven, sir?"

"Certainly it will. That is what it is here for."

"Oh, thank you; how nice!" twittered the visitor, taking a large Madras handkerchief from his coat tail pocket, shaking it out, and wiping his brow with it. "That being the case, if you will be kind enough to let me have one on Tuesday, sir, you will do me a great personal favor. You see, sir, Tuesday is my birthday, and I want a patent on it so no one can use it for birthday purposes, sir, except myself."—Washington "Star."

* * *

DON'T BRAG.

Once there was a smart young man who had a weakness for claiming everything. If any improvements around the shop, he was the one who made them; if any machine made by the concern was spoken well of, he was the one who invented the machine, and so on to the end of the chapter.

The concern with which he was identified was in the habit of having the machinery of their make well spoken of, and this was the rock on which this young man was wrecked, so to speak. One day he called at a shop in another town which had recently bought a machine of the concern with which he was connected. Soon as it was known where he was from the manager asked: "Who inspects the machinery made in your shop?" The young man swelled with pride: "I do; and let me tell you that nothing is allowed to go out of that shop until I look it over, either."

"I DO."

"COME UP STAIRS WITH ME."

You are just the man we want to see," said the manager. "Come upstairs with me. See that machine? What do you mean by passing such a poor job as that? Why, it's the worst built machine I ever saw, etc., etc., etc."

"IT'S THE WORST BUILT MACHINE I EVER SAW."

Alas! it was true. It was a poor job, which by one of those mistakes which occasionally happen in the best of shops, (and families), had gone out wrong; and the young man, on account of his weakness for "showing off" had got himself in a scrape, and now says he don't think much of that concern anyhow. I guess he don't, because he hasn't called there since.

SLOW PAY.

AMONG THE SHOPS.

UP THROUGH NEW YORK STATE AND OVER THE CANADIAN BORDER.

MAKING A 1¾-POUND HAMMER BY HAND IN TEN MINUTES.

During a recent trip over the New York Central Railroad, I visited the repair shops at Depew, and, having noted the attention given to little details all along the line of the famous Empire State Express, I was not surprised to find a plant equipped for handling the work required on the rolling stock of a modern railroad, but I was hardly prepared for what I saw in the blacksmith shop.

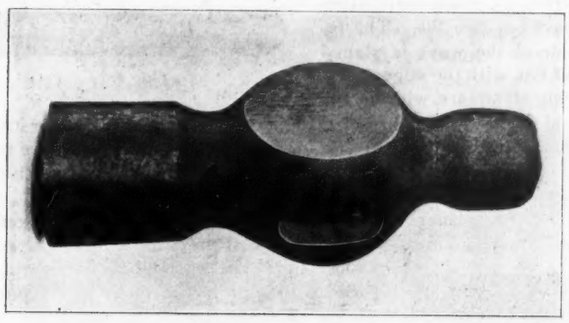


FIG. 1. THE 1¾-POUND HAMMER. (REDUCED)

Besides the numerous air hoists and other conveniences, air motors are provided for driving certain machines, so that the supply of compressed air can be drawn upon to do the various odd jobs that are demanded outside of the regular working hours without starting the engines or running any unnecessary machinery.

After an interesting tour of his department I was turned over to the tender mercies of Mr. M. K. Dobbins, who is evidently a blacksmith of resources and ability, with a whole-souled interest in the business.

I must not take the space to mention all that I saw of interest at Depew, but the hammer illustrated in Fig. 1, weighing one pound and twelve ounces, was made from a bar of cold steel (Sanderson's best) in less than ten minutes, and it would be unfair not to explain how it was done.

Mr. Dobbins interrupted one of his men on another job, and told him to see how quick he could make a hammer.

While the steel was heating he selected his tools, and the general outline of the hammer was made under the steam hammer in formers held by a helper. Two blows between the smooth faces of the steam hammer flattened the sides, and the eye was put through, and the finishing touch put on at the anvil. As fully one-half of the time was consumed in heating and reheating the metal, it will be seen that it was a rapid piece of work well done, and it impresses me as a better exhibition of ability than a more intricate job, requiring hours to execute, and having no application whatever to actual work.

Possibly there was some sleight-of-hand about it, but I do not think so, as it was not separated from the bar until practically finished.

AT LOCKPORT, N. Y.

"Rotary Planer" is the name applied to the subject of a photograph taken at the Holly Manufacturing Company's, Lockport, N. Y., and reproduced in Fig. 2. It consists of an inserted tooth mill, which in this case is at work on the face of a balance wheel 13 inches wide and 50.78 feet in circumference (16 feet 2 inches in diameter), weighing 35,050 pounds. It was built by the Bement-Miles Company, and the teeth in the mill are set in a circle 5 feet in diameter, which makes about two revolutions per minute. A pair of these wheels were being built for a pumping engine for installation at Evansville, Ind., and a cut one-half to three-quarters of an inch deep around one of the wheels had just been completed in two hours and forty-seven minutes. With the machine all ready, the small amount of time that it took to place the wheel in position with their two traveling cranes showed that it would require but a little more than three hours to set the wheel and mill around it. The sides of the wheels were not machined, and only a single cut was taken over the face, the object being merely to remove the effects of the draft on the pattern. The general foreman (Mr. Perry Stowell) informed the writer that the finest feed on the machine is one inch per revolution, and a single offset tool is used for finishing cuts because it is so difficult to grind or adjust a gang of cutters good enough for finishing. Specimens of work recently finished were seen on the floor, showing a good finish with the one-inch feed per revolution.

Some large flanged joints are shown in the picture, and the advantage of this machine over the ordinary planer is most apparent in finishing similar connections on the large shapeless pipes, etc., common to their work.

A UNIQUE LATHE.

Carlos Holly, of Lockport, N. Y., designed and built two lathes having some special features, and Fig 3 is from one of them.

The headstock is pivoted at the front end to adapt it to taper

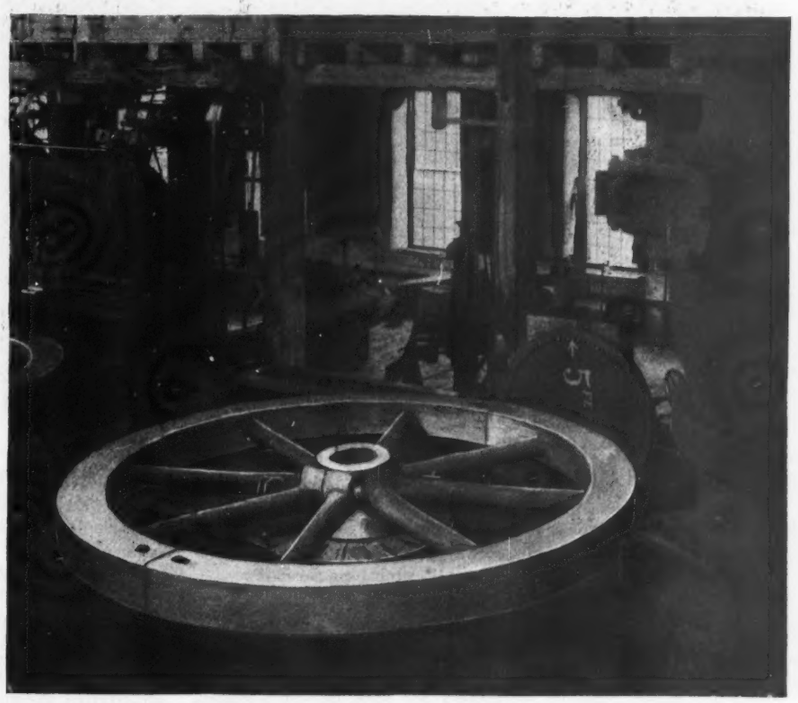


FIG. 2. MILLING THE FACE OF A 16-FOOT WHEEL.

boring and thread cutting. A worm gear, *B*, driven from the spindle transmits motion to the carriage through the rack *C* and change gears on the vertical shafts *D* and *E*, and takes the place of a lead screw. The intermediate gear *F*, carried by *G*, is adjusted in the usual manner. In thread cutting the carriage is locked to a rack jointed at *C*, which meshes with a gear on the lower end of the shaft *E*. For left-hand threads the visible part of the rack is swung under so as to mesh with the gear on the back side. The rack has a motion of twelve inches only, but before locking the carriage it can be moved along the ways and the twelve inches of thread cut at any desired point. As the carriage is locked to the regular feed rack, the tool can be ad-

vanced or retarded independently of the thread cutting mechanism by turning the regular feed rod *H*, which makes it convenient to work on either side of the thread at will and facilitates the resetting of a tool.

The lathe is belted to run in one direction only, and by touching a latch on the handle *J* the clutch *L* is instantly disengaged by a spring through the connections *N*, the tool drawn back out of the thread and the carriage returned to the starting point by a weight attached to a small wire rope winding on *M*, so that the cross feed handle *O* is used only to adjust the tool for the successive chips. These movements are also adapted to internal thread cutting by hooking the spring on a different pin.

The Carlos Holly lathe is not a new thing and it would not be the first that I would think of buying to fit up a shop with; and evidently Mr. Holly does not expect to put it on the market. It has some good points, however, and the quick return motion is a time saver for lathe builders to think about. Provision is made for tripping the latch automatically, but it is seldom used.

The joint in the rack permits its end to swing with the rest of the gearing, which all goes with the headstock when it is set over for taper thread cutting, so that the relation of the parts is practically unchanged. The handle *P* is on a rod that passes under the bed and connects with another by gearing to operate the rise and fall feature at the back side of the carriage.

Now that I have described the construction of the lathe, I will

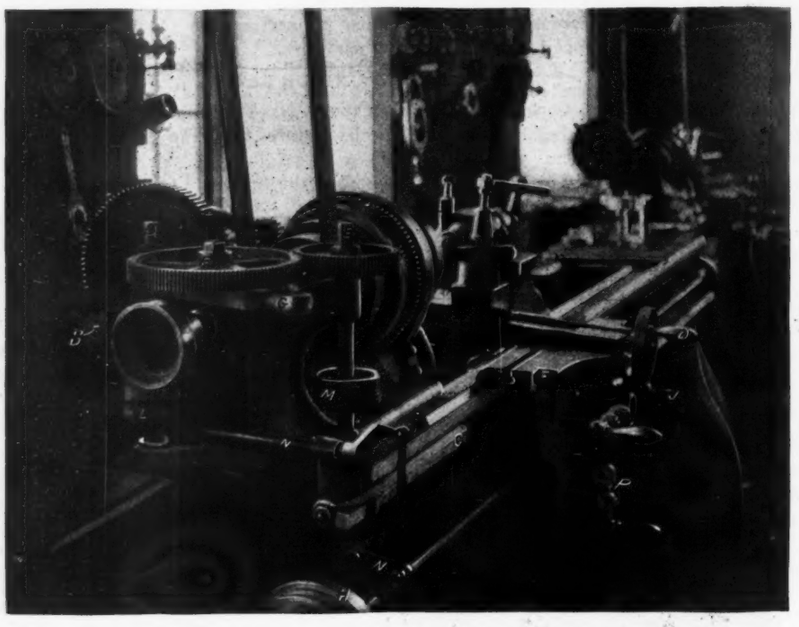


FIG. 3. CARLOS HOLLY LATHE, WITH NOVEL SCREW-CUTTING DEVICE.

give a problem. I don't know just what pitches were used, but will assume that the pinion on the lower end of *E* is ⅜-inch circular pitch and has 16 teeth. With 72 teeth in *B* driven by a triple thread worm of 1-inch pitch keyed to spindle, what gears will be needed on *D* and *E* to cut a 11½-pitch pipe thread?

Will *B* need to be a right or left hand worm gear?

A CHINESE TYPEWRITER.

Mr. Holly builds special machinery, and he is the only man that I know of who ever built a Chinese typewriter. It is said that some 40,000 separate characters are used by the Chinese, but only 4,500 of them were called for by the missionary, and these were arranged on a disc 30 inches in diameter. About 90 per cent. of his writing could be done with one-third of these. The other two-thirds were used only occasionally, and with what might properly be called an experimental machine, the missionary for whom it was built (Mr. Sheffield), could write about four times as fast as a Chinese student could by hand.

FROM SOME CANADIAN SHOPS.

The works of John Bertram & Sons are located at Dundas, Ont., and represent Canadian practice in machine tool building about as well as any. Judging from their equipment, which is mostly new, they believe in their own machinery, but do not hesitate to put in American tools that will enable them to do better work, and just previous to my call a lead screw made by Brown & Sharpe, costing about $10 per foot and guaranteed accurate to within one-thousandth of an inch in three feet, was put on to their screw cutting lathe that they might be able to supply their lathes with a lead screw of superior accuracy. I know of more than one American lathe builder who could improve his product in the same way.

I was amused to learn from this company of the positive demand that still exists in the Canadian market for chains on lathes in the place of belts for driving the feed rod. The gap is another popular feature and no doubt has its good points.

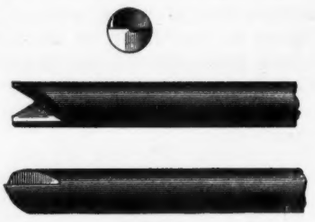


FIG. 4.

The Bertram milling machine closely resembles the Brainard, while their lathes have but two V's. The inside of the ways is planed off flat, with the edges dropping off square, with the top and the head and tail stock fitting down between them. The strap and tightening bolts are arranged so as to always bring the tail stock firmly against the same side every time it is locked, without producing any tendency to spread the ways of the lathe.

All their planers are driven by cast iron worm and worm gears, and I have good reason to believe that they are both durable and successful. The worms have a quadruple thread of four inches pitch and a pitch angle of 22 degrees.

The pitch diameters of the worms are a little more than three inches (3.18 inches), and the thread is B. & S. Standard. They drive at a pitch line velocity of 155 feet per minute and return at about 620 feet. I mention these details on account of the articles on worm gearing that have previously appeared in this paper, believing that the knowledge of worm gearing that the Bertrams have derived from experience would be of practical value to many of those interested in the subject.

Fig. 4 is a simple, cheap and practical mill, with all of the good points of the "Cotter mill" described by "Milo" in the February, 1898, issue, with some advantages over both the cotter mill and end mill for die sinking, milling key seats and similar work, where it is desired to avoid the effects of crowding—a jog at the corners.

If properly made these mills are stiff enough to take a cut of reasonable depth, and can be readily sharpened. From their construction, the teeth naturally serve as a hollow mill to remove any stock that projects up inside. The makers of this one have a set of split chucks for holding the different sizes of drill rod, from which most of them are made, enabling them to be gripped as close to the points as desired when in use.

A TURRET ATTACHMENT FOR AN UPRIGHT DRILL.

Having a contract to supply a large number of pieces in short order Mr. Charles James, of Hamilton, Ont., devised the turret attachment shown in Fig. 5, and feels well pleased with the results that he is obtaining from it in his shop at that place. He is using the device on one of Bertram & Son's upright drills.

One of the pieces is shown in the photograph at *A*, and is gripped by the split chuck *B* fitting the drill spindle; and the flange and taper hole, about one and a quarter inches in diameter, are finished by *C D* and *E* held in the turret. *F* is a stop for gauging the depth of the taper reamer. It is fastened to the turret close to its shank, and the roller meets the face of the work at the proper point.

B is replaced by *G*, which has a cone shaped projection fitting the taper hole in the work, and two bolts *H H* to grip over the flange and hold it when it is fed down into the roughing tool *I*. *J* squares up the shoulder, chamfers the corner and prepares the piece for the two threading dies *K* and *L*. *I* and *J* have hardened stops in the center that are adjusted to meet *G*, and cutters for

facing off the end of the flange to the right length. At first both dies were held rigidly, but it was found that better work was obtained by allowing the holder of the finishing die, which projects down four or five inches below the die, to stand on a "wobble joint." As regards the capacity of the rig, all of the work on the small end of about fifteen pieces can be done in an hour, and there is work enough to keep it going at that rate night and day for two or three months. The lever *M* operates the locking pin of the turret. The drill press spindle is belted to be driven in both directions by power.

Only about twenty machinists are employed in the repair department of the Canada Screw Company, but it is probably the best equipped machine shop in Hamilton, and being a branch of the American Screw Company, it is not surprising to find nearly all its tools bearing the name of some American builder. I am indebted to the kindness of its superintendent for what proved to be a very pleasant and interesting tour of the factory, where my attention was attracted by one of the roll screw machines because

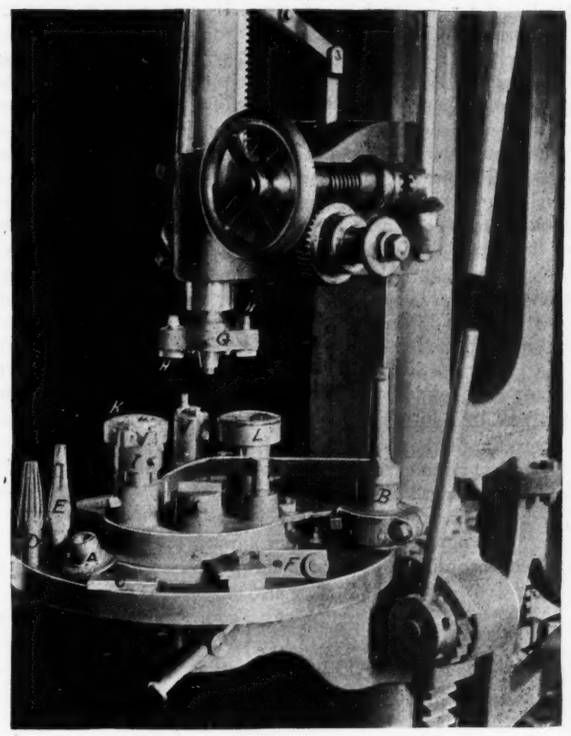


FIG. 5. DRILL-PRESS TURRET ATTACHMENT.

it was being fed by hand. The machine was threading screw-eyes which have a wood screw thread and gimlet point; but to roll a good thread is not the part that bothers.

It seems to be no easy thing to invent an attachment that will pick up the pieces and feed them into the machine, one at a time with the point down, at the rate of 100 to 125 per minute, for as yet they have not devised an entirely automatic rig for feeding them. By hand feeding about one-quarter the capacity of the machine can be realized. Think about it; can it be done?

BRIEF NOTES.

Bicycle bearings loaded by machinery sounds like a joke at first, but when one stops to think how long it would take to count out enough balls and put the right number into each bearing of a year's product in some of the large factories, it is not surprising to find a machine for doing the work.

Each shop has its own method, but I saw a very simple home-made rig for doing this at the Syracuse Arms Co., Syracuse, N. Y. It consisted of a hopper mounted at a suitable height above the bench, with a small brass pipe and two gates arranged and operated like the shot pouches used with the old muzzle-loading shotguns, measuring out just enough balls for a bearing each time the end *L*, Fig. 6, of the lever was pressed, and they dropped into the bearing held under the end of the tube.

MEASURING FOR FORCE FIT.

Here is a way of measuring a shaft with ordinary calipers when it is desired to leave it enough larger than a given hole for a forced fit, that was suggested by a mechanic in one of the shops of the New York Central Railroad.

It takes considerable experience to enable one to see inside calipers to a hole and then transfer the size to the outside calipers in the case of a forced fit by looking through the space between their measuring points.

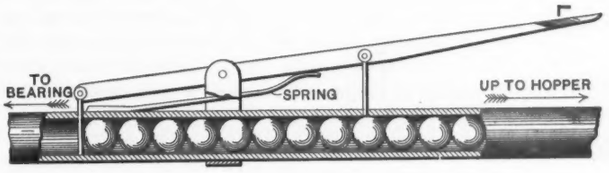


FIG. 6.

By the following method, however, both the inside and outside calipers are set to the exact diameter of the hole, and the allowance is made in measuring the shaft by placing one leg of the calipers at a point *C* on one side of the shaft and measuring across each side of the center to the points *A B* on the opposite side spanned by the calipers (without springing), as shown in Fig. 7.

The distance *A B* varies, of course, with the diameter of the shaft and the amount of the allowance for the fit, but it can be estimated fairly well after a little practice. On the whole, this mechanic thinks the results by this method would probably be

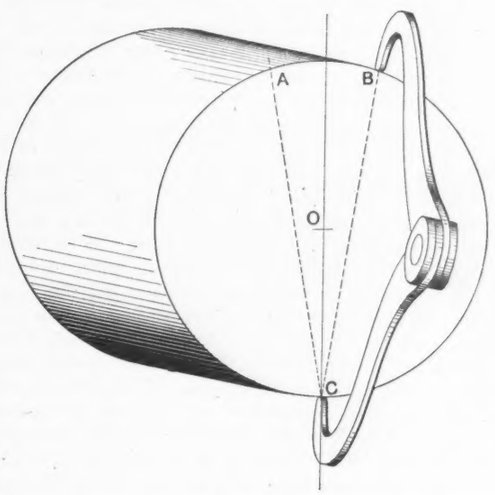


FIG. 7.

as good at least as those obtained by springing the calipers over the shaft and depending upon the "feel," or by trying to set the outside and inside calipers with a space between them.

I don't want to be understood as recommending the methods mentioned where an inside micrometer or any other more civilized appliances are available. A L G.

* * *

The gun trials of the English naval vessel Illustrious demonstrate the fact that the 46-ton breech-loading gun of the navy may almost be classed now as quick firing, for the details of the mechanism for training, elevation and loading have been so perfected that the time between two shots was found to be only 47 seconds; while from the discharge of the first to the delivery of the third the time elapsing was only 107 seconds. This was attained with a projectile of 850 lbs., and a charge of 166 lbs. of cordite. The four guns of the ship in two minutes could thus fire at an enemy 14,000 lbs. of projectile, each of the sixteen shots being fired with a velocity which gives a range of fourteen miles, and a muzzle energy of 33,020 foot-tons, so that the two minutes' firing represents a total energy of 528,320 foot-tons. In other words, it is equal to lifting a 14,000-ton battleship a height of 35 feet. Truly, the gun discharge of a modern battleship may be compared to a volcano. The only manual labor involved is in lifting the charge, which is in two cannisters, each of 83 lbs. weight, from the hoist on to the loading tray. —"Mechanical Engineer."

WHY STUDY ALGEBRA?

WHAT ALGEBRA IS FOR, WHAT IT IS NOT FOR, AND HOW TO STUDY IT.

RETSEL.

It is not easy to talk about algebra to a man who has never studied it. To fully comprehend what algebra is, what can be done with it, and what its limitations are, it must be studied. It is not to be wondered at, therefore, if those who have never studied the subject do not see into it, even after there has been a good deal of explaining done. In fact, I believe that most of those who do study algebra either do not understand just what can be done with it, or else have an entirely wrong conception of its purpose.

What Algebra is Not For.

In any book upon algebra will be found a great many examples, of which the following are fair samples:

1. A man rows down a stream, which runs at the rate of 3½ miles per hour, for a certain distance in 1 hour and 40 minutes. In returning it takes him 6 hours and 30 minutes to arrive at a point 2 miles short of his starting place. Find the distance he pulled down the stream and the rate of his pulling.

2. A person who saved every year half as much again as he saved the previous year, had in seven years saved $2,059. How much did he save the first year?

3. Find two numbers in the ratio of 2½ to 2, such that when each is diminished by 5 they shall be in the ratio of 1⅓ to 1.

Now, students often get the idea that the sole end and aim of algebra is to enable a person to solve examples like these, and to do it easier than they can be done by arithmetic; and as examples of this class do not enter into everyday calculations to any extent, it is perfectly natural that algebra should come to be regarded as a plaything that is very good to amuse, but nothing more. Doubtless examples of this character serve the useful purpose of training the mind, just as does the study of Greek, and it is true that they can be solved considerably easier by algebraic than by arithmetical methods. Their solution is not, however, the chief end of algebra, and in fact it is one of the least valuable ends to which it can be put. In working such examples, either by arithmetic or algebra, much thought and study must be given to reasoning them out and deciding what steps must be taken; after that, the bare arithmetrical or algebraic figuring, as the case may be, is generally quite easily done, and it is no more to be supposed that the object of algebra is to solve examples of this class than to suppose it is the object of arithmetic. Few examples, moreover, can be done by algebra that cannot be done by arithmetic. The rules for many examples that are often worked by arithmetic have to be derived by algebra; but after the rules have once been derived, the calculations can be made by arithmetic.

The advantage of algebra, therefore, is not that it enables one to solve puzzling examples, nor even to solve examples that cannot be done by arithmetic. It will not pay a bookkeeper to study algebra, except with the idea of general training, because he will not use it. Neither will it pay a machinist, pattern maker, nor an engineer, unless he intends to follow it up with a study of the principles of mechanics, or of steam. A machinist has little or no use for algebra in his everyday work; but if he wants to find out more about the how and why of things and study into general principles, it is, in my judgment, the most important subject that he can take up, next to arithmetic and mechanical drawing.

The Advantage of Algebra.

The great practical advantage of algebra and the only advantage that it can have for most people is that it enables one to handle formulas.

A formula is a statement of a general rule, abridged by means of symbols. It would not be a bad definition of algebra for practical purposes to say it is that science which deals with formulas; and if the student should always keep this definition in mind and try to see what bearing the different parts of algebra have on formulas as he comes to them, it would be of very material assistance to him.

We will now consider a little more in detail what formulas are and what they are used for, which will give us the answer to our question "Why study algebra?"

What is Gained by Using Formulas.

Take for illustration the subject of the horse power of a steam engine, and if any reader has difficulty in understanding what follows, let him read the very clear article upon horse power, by Mr. J. B. Richards, in the February issue of this paper. The arithmetical rule for finding the horse power is as follows:

Multiply together the mean effective pressure per square inch on the piston; the length of the stroke in feet: the area of piston in square inches, and the number of strokes per minute. Divide the product thus obtained by 33,000, and the quotient will be the horse power.

This is simple, and if we knew the mean effective pressure of an engine, the length of stroke, the area of the piston and the number of strokes per minute, we could easily calculate the horse power.

But suppose that instead of having to calculate the horse power this quantity were known, as well as the steam pressure, the length of stroke and area of piston, and it was desired to tell just how many strokes per minute the engine must make to develop the required horse power. How many, by using the above rule, could work out the result? The rule tells one thing, and one thing only, and that is how to calculate the horse power of an engine. When it comes to finding the number of strokes that a certain engine must make in order to develop a given horse power, there must be another rule telling how to do it. And so, in order to solve all possible examples about the engine a rule will be needed telling how to find the pressure necessary to develop a specified horse power, one for finding the length of stroke when the remaining values are known, and still another for the area of the piston. Five rules in all for working out these five simple examples! I do not say that everybody finds the five rules necessary, but to make the matter perfectly plain to everybody they would be required. This is the arithmetical way of dealing with the horse power problem.

In taking up the problem by algebra the rule for finding the horse power would be abbreviated by the use of letters and would be stated as a formula, thus:

Let H = the horse power.
P = mean effective pressure per square inch.
L = length of stroke in feet.
A = area of piston in inches.
N = number of strokes per minute.

Then, according to the statement of the rule,

$$\text{Horse-power} = \frac{\text{Pressure} \times \text{stroke} \times \text{area} \times \text{No. strokes.}}{33{,}000}$$

Or using the letters instead of the words,

$$H = \frac{P \times L \times A \times N}{33{,}000}$$

This brief way of stating the rule is called a formula. The letters are written instead of the words and the operations of multiplication and division, directions for which were given in the rule, are here indicated by the signs $\times$ and the dividing line of the fraction which denotes division.

The formula thus affords a complete survey of the problem at a glance and enables us to deal with it with great facility.

To obtain the horse power by aid of the formula, substitute for the letters their values in the given problem and perform the indicated operations.

Now suppose, as before, that it was desired to find the number of strokes per minute required to produce a given horse power. Instead of having to hunt up another rule, a person understanding algebra would rewrite the formula so that he could readily find the value of N, the number of strokes. The formula thus rearranged would be as follows:

$$N = \frac{33{,}000\,H}{P\,L\,A}$$

He would then write for H, P, L and A their values, and from them get the number of strokes, N; and the same method would be followed in obtaining the value of any other term that was desired. One of the important missions of algebra is to explain how to re-arrange formulas, putting them into the form desired.

This brief illustration shows in a very incomplete way the advantage to be gained from formulas. The importance of an ability to use formulas can scarcely be overestimated. With few

exceptions the best books are full of them, and most of the best writers use them freely. These facts ought to be good evidence that formulas are worth looking into at least, and reason enough why anyone who is after information should learn how to use them in order to find out what some of these books contain.

In closing it may not be out of place to give a few hints about the study of algebra.

Algebra is not an easy subject to pick up by oneself. It would be better at the start to take a few lessons from a competent instructor, and if possible to keep on with the instructor through the whole subject. The intending student should also be well grounded in arithmetic, especially the chapter on fractions.

The particular text-book is not important. Get the elementary algebra that is in use in the schools in your town or city. It is generally of advantage for two or three persons to work together, as the sticking points of one can very likely be cleared up by another. The first few chapters deal with addition, multiplication, division, factoring, fractions, etc., subjects that are met with in arithmetic. This part is not strictly algebra, but it is more properly called literal arithmetic, since letters are used as well as figures to represent the numbers. After these preparatory chapters come "Simple Equations," and with them algebra proper commences. This is the important part for the student. Learn as soon as possible how to solve simple equations, and impress upon your instructor, if you have one, that you wish to have your work count in this direction. A formula is simply a special form of what is called an equation, and to understand formulas you must understand equations.

When simple equations are mastered it will be desirable to get an insight into the practical application of algebra, and the two best books for the purpose, with which I am acquainted, are Jamieson's Elementary Applied Mechanics and Jamieson's elementary work on the steam engine, both for sale by the J. B. Lippincott Company, Philadelphia. Either of these books will give a clear insight into the mysteries of the science of algebra, and until some such book is taken up the student will not, in my opinion, have a clear conception of its practical value. Having once gotten into the subject, I am sure that a little study of elementary books like the above, where algebra is used in a very simple way and is clearly explained, will be a revelation to most mechanics who cannot now understand the use of algebra.

* * *

COMPARATIVE FIGURES.

There is great variety and equal diversity of opinion as to the influence of temperature on the transferance of heat in the cylinder of a steam engine. But throwing to one side all fine-spun calculations and assuming that a cylinder of four times the capacity of another offers four times the facility for the condensation of steam, and that the transferance of heat is directly as the difference in temperature, it is interesting to note how figures will sustain the generally conceived opinion of the economy obtained by compounding the modern steam engine as operated by steam of fairly high pressure. For the purpose of comparison, take as an example a two-cylinder compound, boiler pressure 140 pounds, ratio of cylinders 1 to 4, cut-off in high pressure at about ¼ stroke. These figures are taken because there are at hand, at this writing, indicator diagrams from an engine operating under these conditions. Computing them shows the variation as between initial and back pressure temperature in the high-pressure cylinder is 121 degrees, and in the low pressure 117 degrees. Add one-fourth this variation in the high-pressure cylinder (to reduce it to terms of the low) and the actual and equivalent variation in the low-pressure cylinder is 147 degrees.

Now assume that the work is done in the low-pressure cylinder alone, the engine being then a simple engine. The variation in temperature will then be 223 degrees instead of 147. The difference against the simple engine is 76 degrees. If there was nothing else to it we might conclude that the saving by compounding was, under the circumstances stated, nearly 35 per cent. Allowing for increased friction and for conditions in this instance rather favorable, possibly, to compounding, this showing would appear to sustain the proverbial 20 to 30 per cent. saving by compounding. Of course, the figures given are comparative rather than positive; but, picking all the flaws possible in them, they are of interest, perhaps.

New York City. FRANK GLEASON.

DYNAMOMETERS—2.

MORE EXAMPLES OF TESTS WITH THE WEBBER INSTRUMENT - AN INTERESTING ACCOUNT OF THE EMERSON POWER SCALE - OTHER KINDS OF DYNAMOMETERS.

SAMUEL WEBBER.

Before closing my account of the balance dynamometer*, I will quote a few more instances from my notebooks, showing its application, and the accuracy with which varying amounts of power may be determined. The first one I turn to is a series of weighings made at Manville, R. I., in 1873, to ascertain the amount of power consumed in the various parts of a spinning frame, for producing cotton yarn, and any of your readers who are familiar with the operation will readily be able to follow the changes. I will omit the gross weight in the steel-yard, and the division by seconds, and only give the foot-pounds and horse-power resultant.

The frame tested was one of 208 spindles, from the Bridesburg Machine Shop, running at 8,300 revolutions per minute, and spinning No. 40 yarn.

	Ft.-lb.	H. P.	Dim.
The weight in full operation was.....	993.	1.806	
The weight, yarn broken, traveler stopped	893.	1.624	10%
Weight, roving broken, draught stopped..	843.37	1.536	5.08%
Weight, top rolls lifted off.....	816.66	1.485	2.69%
Weight, bottom rolls stopped.....	766.68	1.394	5.03%

This left the power, for cylinder and spindles..... 77.11%

The bands were then taken off and the spindles stopped, the cylinder giving only 100 ft. lb. =.0.182, or 10 per cent., and the spindles only were thus found to be 67 per cent of the whole power consumed. It is hardly fully comprehended how much of the power is consumed in speed, or how a small simple-looking machine, at a very high speed, will consume a great deal of power, while a much larger or more cumbrous one, at a low speed, will take very little.

I find an instance on another page of my note-book, in December, 1883, where a "John A. White" single cylinder wood planer, at 5,000 revolutions per minute, took 3.57 horse-power, simply to run it empty, and 8.006 horse-power when planing boards, while a cumbrous indigo mill, in the next building, which could be heard half over the yard, at 12½ revolutions per minute, only required 0.556 horse-power! Here I had to use two pair of countershafts in order to speed the dynamometer up high enough to use it, and then to reduce the speed again to the normal rate of the indigo mill. Another case in which I had to put up extra counters was to weigh the power of a double rotary fulling mill, fulling two strings of heavy beaver cloth at 96 revolutions per minute. By speeding up the dynamometer and reducing again to the mills, I easily found them to take a trifle over 3 horse-power, and in this way the dynamometer can be made available in many cases where it would otherwise seem to be impracticable.

It will be readily seen from the above notes that there are limitations to the use of this form of dynamometer, for its parts have all to be strong enough to actually transmit the total power weighed, and that, although to some extent attainable by high speed, is confined to the velocity at which it is safe to run gear teeth. Although I have run gears of ⅜ circular pitch up to 4,500 revolutions per minute, on occasion, I would not like to do it regularly or to recommend it to others. The indicator is, at its best, only an indicator, as its name implies. It gives on an area of ½ square inch, the pressure of steam, per square inch, from which, multiplied by the piston area and travel, the power delivered in the cylinder can be calculated, but it does not give an accurate record of the power received from the engine, and consumed by the machinery.

There have been many attempts to build a dynamometer which, without being too cumbrous, would actually weigh the power consumed to an amount of more than 20 or 25 horse-power, which is as high a point as the writer has attempted to reach with the transmission dynamometer" described, and the most successful attempt yet, to his knowledge, has been the "Emerson power scale."

Emerson Power Scale.

This dynamometer was introduced somewhere about 1870. James Emerson, an old sailor of an ingenious mechanical turn of mind, had invented an improved capstan, which was very success-

* In the March number.

ful, and afterward "came to anchor" in Lowell, Mass., where his daughter was employed as a copyist in the office of the late Jas. B. Francis, the engineer and agent of the Locks and Canals Co. In this way Mr. Emerson's attention was called to Mr. Francis' experiments in testing the power of turbines, and he conceived the idea that he could apply the principle of the "Fairbanks platform scale" to this operation, and got up a "rotary platform scale" for this purpose.

It did not prove a success, and Mr. Emerson returned to the old form of "Prony-brake," and afterward established a testing flume at Holyoke, where he achieved a considerable reputation and rendered great service to the manufacturing community by his long continued tests of various forms of turbines.

While it may be stated that the failure of this form of dynamometer in turbine testing was due partly to the complication of

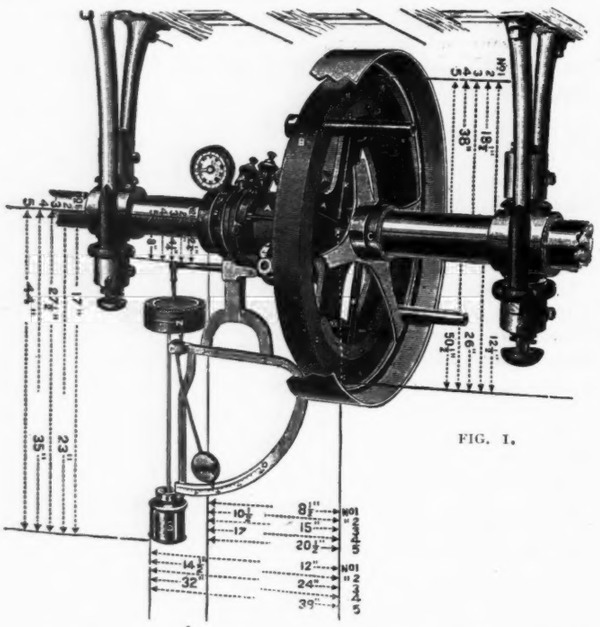


FIG. 1.

working parts, with long leverages of 10 to 1, several times multiplied, and having considerable centrifugal action, and partly to the inevitable slip and "chatter" in pinching up the brake strap on the friction pulley, Mr. Emerson still held to the idea, and afterwards perfected it in the form of the "power scale," for weighing "steady power," for which it has proved very useful.

The cuts represent these instruments as built by the Florence Machine Co., Florence, Mass., No. 1 being the larger pattern as applied to shafting.

The belt pulley is shown with a portion of its rim broken away, so as to expose the arms and the way in which they bear on the projecting studs of the dynamometer. The pulley is loosened from the shaft so as to move freely and throw the strain on these projecting studs. These are inserted in the outer rim of the dynamometer, which is connected to the hub, which is put on the shaft, by a series of levers, the last or third one of which pulls on the bent lever steel-yard shown at the left-hand.

Instead of a movable poise, the minor divisions of weight are measured by a light arm lifting along a quadrant, properly graduated. As there are three of these levers, each with a ratio of 10 to 1, one pound on the steelyard represents 1,000 pounds pull on on the first lever, and 1-10 of a pound on the quadrant finger, with a fourth leverage of 10 to 1, also represents 1,000 pounds when raised to the level.

Number	Size of Shaft.	Capacity at 100 Revolutions per minute.
1	1 1/16 inches.	4 horse power.
2	2 1/16 "	9 " "
3	2 15/16 "	27 " "
4	3 15/16 "	68 " "
5	4 7/8 "	180 " "

The dial plate shows the number of revolutions per minute, and is "timed" by a watch.. The figures on the cut show the dimensions of the different sizes, given in the table. This class of "shafting dynamometers" are all made with "split hubs" and can be attached to any line of shafting without taking it down.

Cut No. 2 represents the smaller size, as applied to a cotton spinning frame. This is self-contained, and is applied by taking off the loose pulley on the end of the shaft and fastening the power scale in its place, and removing the key or set screw from the tight pulley, so that that becomes a loose one, and acts by its arms on the levers of the dynamometer. The writer knows this instrument to weigh accurately, but it requires skill and care in its manipulation, for it will be easily seen that while this long series of compound levers is steady when quiescent as in a platform scale, it becomes liable to be vibratory and "joggly" when put in rapid motion. There is also some power consumed by the centrifugal "throw" of the levers, which form a "tare" which must be deducted. To ascertain this the whole lever system is connected with the permanent hub by a sliding bolt, which can be withdrawn so as to put the levers in operation without transmitting any power, when that required to move them at the proper speed can be read off from the quadrant and deducted from the final weighing.

Absorption Dynamometers.

I had occasion to refer to Mr. Emerson as trying this plan for testing turbines and being forced by all this vibratory action to return to the old "Prony brake." I should, perhaps, have mentioned this earlier, as it belongs to the same class of instruments as the indicator, viz., an "absorption dynamometer" instead of a "transmission" one, and is the only known instrument for weighing accurately the power delivered by any prime motor, whether steam engine or water wheel. It is illustrated in the October number of MACHINERY and sufficiently explained already, but the writer in his own practice avoids the leverages of the platform scale, and arranges his brake lever to lift an actual dead weight. This requires handling a few more pounds of weight, but it is positive and certain.

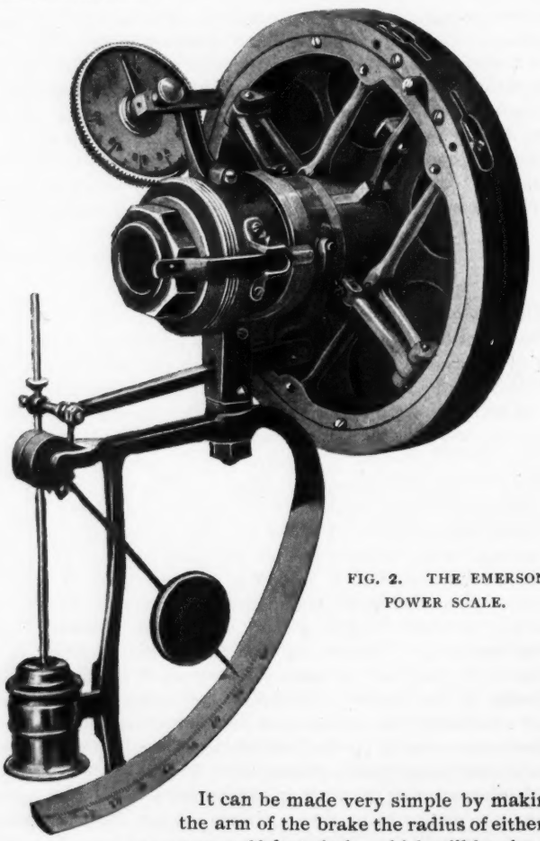


FIG. 2. THE EMERSON POWER SCALE.

It can be made very simple by making the arm of the brake the radius of either a 33 or a 66-foot circle, which will be almost exactly 5′ 3″ or 10′ 6″. Then in the first case a 10-pound weight on the lever, at 100 revolutions per minute, will have described 3,300 feet, were it free to move, and represent 3,300 × 10 = 33,000 = 1 horse-power; in the second case, at the same revolutions per minute, it would be 2 horse-power.

You have only to multiply the weight in the scale by the revolutions per minute and strike off three decimals. Or the brake arm may be 8′ 9″, or the radius of a 55-foot circle. In this case count the number of seconds taken to make 100 revolutions, and by that number divide the number of pounds in the scale. This

is a very convenient plan for high speeds, by having a worm gear and striker which rings a bell every 100 revolutions.

In all these operations the writer has found it advantageous to use an ample "dash-pot," or regulator, to counteract the tremble and "chatter" due to the slip, of either the brake clamp or the belt on the pullies, and with the brake clamp, where slip is necessary, and should be uniform, he has found the best lubricant to be good, strong soapsuds.

These dynamometers, as mentioned, complete the list, so far as the writer knows, of those using positive weights, and with the exception of the Emerson power scale, are not on sale in open market, though any one wishingt to procure one of the form I have so fully described can probably get one at short notice, by application to the Trenton Iron Co., Trenton, N. J.

For many purposes, however, the use of a spring balance is sufficiently accurate and very convenient, if they are not loaded to such an extent as to set or strain the springs. The writer has used them for small amounts of power, applied to the Prony brake referred to as being shown in the October number of MACHINERY, but attaching the spring scale to the floor and running the friction pulley so as to lift on it, instead of pressing down, in the same way as when positive weights are used. In all cases, however, the apparatus must be perfectly balanced over the center of motion when at a state of rest, so that the weight of any part of it will not affect the load on the scale.

Chas. Kastner, of New York, makes an excellent spring balance for such purposes, which I have used.

In cases of direct linear motion, such as the draught on a carriage or a railway train, the spring dynamometer is the only practicable form, and may be applied either in the form of a coiled or an elliptic spring, its compression having been previously ascertained, and a proper scale graduated on which to read the pull. Care should always be exercised however, in all cases where springs are used, not to overload them beyond the elastic limit.

I referred in my previous article to the use of springs in a rotary dynamometer and will refer to the form used by Morin. In this the receiving and delivering pulleys were placed side by side on the same shaft. A diagonal cam or cams, attached to the fast pulley, bore on the arms of the loose one, so that the pressure which gave it equal motion, also slid it out in an axial direction on the shaft and compressed a spiral spring. A collar between the pulley and the free end of the spring moved one end of a lever or finger, the other end moving over a dial on which the pounds necessary for the compression were recorded. The distance from the center of the shaft to the cams was the radius of the circle of motion, and this, with the number of revolutions per minute and the weight shown on the dial, divided by 33,000, gave the horse-power. The writer must confess that some of his early tutors in mechanics gave him what was perhaps an undue prejudice against springs where accuracy was required, and he uses and relies on them as little as possible.

Various other forms of dynamometer have been occasionally proposed within the last few years, when the question of power has been brought more prominently into notice than it formerly was, and some of them have been brought to notice at various meetings of the American Society of Mechanical Engineers, but none of them have seemed to the writer to possess any advantages over the forms he has described, or be at once so simple and accurate.

Since writing the previous article it has occurred to me that the machine mentioned as having been made by Mr. Brown, of Lowell, was the same form originally designed by the French scientist, Desaguliers. If I have omitted any matters which seem to deserve mention, I shall be happy to answer any questions at some future time.

* * *

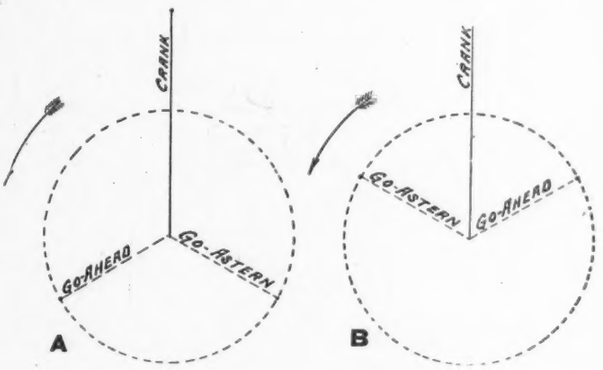
An old floor hand says that bearings for large vertical engines should be scraped to fit the shaft nicely top and bottom, and freely relieved at the sides so as to prevent binding and to give the oil plenty of chance to cover the journal. The way he gets at the right amount of surface to scrape is to tear a strip of paper as long as the diameter of the shaft and lay it in the bottom of the bearing at right angles to the direction of the shaft, the paper extending up on each side of the bottom shell. He then scrapes the bottom of the bearing up as far as the paper extends, and chips, files and scrapes away the sides above that point. The top half is treated in the same way.

MARINE ENGINE DESIGN.—5.

VALVE GEARS, ECCENTRICS AND ECCENTRIC STRAPS.

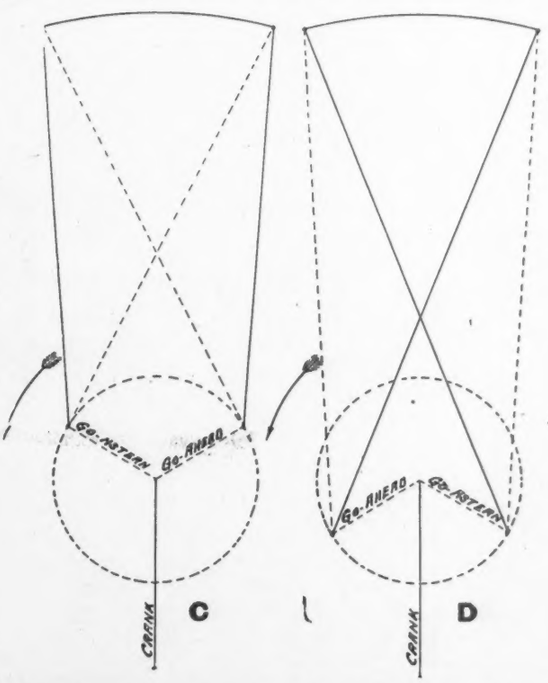
WILLIAM BURLINGHAM.

Slide valves are usually worked by means of an eccentric rotating with the crank shaft. The eccentric and rod is a piece of mechanism used for changing a rotatory motion into a reciprocating or straight line to and fro motion, and is used instead of a crank and connecting rod; of which it is merely a modification to be used in cases where the stroke is short and the load light. The distance from the center of the eccentric to the center of the shaft is called the eccentric radius, and twice this is usually the travel of the valve.



Marine engines being required to run both ahead and astern, they must necessarily be so arranged that the change from one direction of rotation to the other may be made with facility and promptness; the gear in general use for this purpose is the link motion of Stephenson.

In this motion two eccentrics are used, one in the correct position for going ahead and one in the correct position for going astern. Figs. A and B show the proper position of the ahead and astern eccentrics relative to the crank. A shows their position in the case of a slide or piston valve with outside steam, and B the case of a piston valve with inside steam, or when the steam is admitted between the ends of the piston valve, relieving the stuffing boxes and bonnets of the boiler pressure.



In full gear, ahead, the valve will receive the full travel due to the ahead eccentric, and the same for the backing gear; but if the gear is linked up, or, in other words, if the valve stem pin is at some intermediate point between the full go-ahead and go-astern positions, the travel will be a resultant due to the motion of

the eccentrics; varying as the link block is moved, until the block is central where there is no motion, and the engine is in mid gear, or at rest.

The link is thrown from full ahead to full astern position by the movement of the reverse shaft, to which the link is connected by means of a suspension rod or drag link.

The reverse shaft on all but small engines is operated by a reversing engine consisting of either a direct acting cylinder, with or without oil cylinder for braking, or a worm and wheel connection between the reversing shaft and a small motor engine. In small engines a hand wheel only is used.

Open or crossed rods are often the cause of a good bit of argument, yet it is a simple enough matter to determine the type.

If, when the crank is as shown in Figs. C and D, the rods are open or crossed, then they are called open or crossed rods, respectively; the full lines in C representing the open rods, and the dotted lines the crossed. Fig. D represents a case when the steam is taken on the inside of the valve.

The effect of linking up on the operation of the valve is most readily and quickly shown by Mr. McFarlane Gray's diagram. It is a close approximation, and a few experiences in the use of it will enable one to correct even its small errors, and thus be enabled to work the links for the different cut-offs.

Eccentrics.

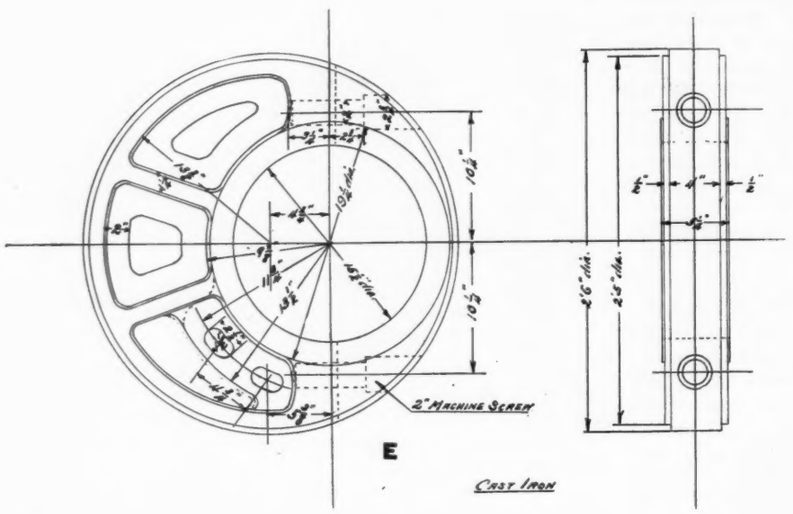
The eccentrics are usually made in two pieces of hard, tough cast iron, the thin portion of the eccentric often being made of wrought iron. The line of division should always be at right angles to the line joining the center of the eccentrics and the shaft. The key-way is usually placed in the centerof the larger portion of the eccentrics. In large engines the eccentrics have two keys about 120 degrees apart. In such cases each key should have side keys that may be drawn out, thus enabling the eccentric to be taken from the shaft. The joint separating the two portions should have a small step to prevent lateral movement of either half of the eccentric.

The halves are usually secured together by two bolts with fillister heads, counter bored, and the hole filled out flush with white metal. In government work the go-ahead eccentric is usually keyed to the shaft and the go-astern eccentric bolted to it, the hole slotted to allow of slight adjustment of same.

The power necessary to move a slide valve on its face is a constantly varying quantity, and the highest ordinary value should be taken, and to obtain this, the gain from using any relief arrangement must be neglected, and the total pressure on the valve taken as the maximum difference between the pressure in the chest and the condenser, usually called 30 pounds. Acting upon the gross area of the valve, calling 2-10 the coefficient of friction for metallic surfaces, then we have L = length of valve in inches, and B = breadth of valve in inches, and stress on valve rod 2-10 ($L \times B \times$ pressure) pounds. It is customary to make the valve gear of the same dimensions for all cylinders.

The pressure per square inch on the eccentric, considering the area as equal to the diameter × width, should never be higher than 170 pounds, and for ordinary merchant work 140 to 150 pounds is preferable.

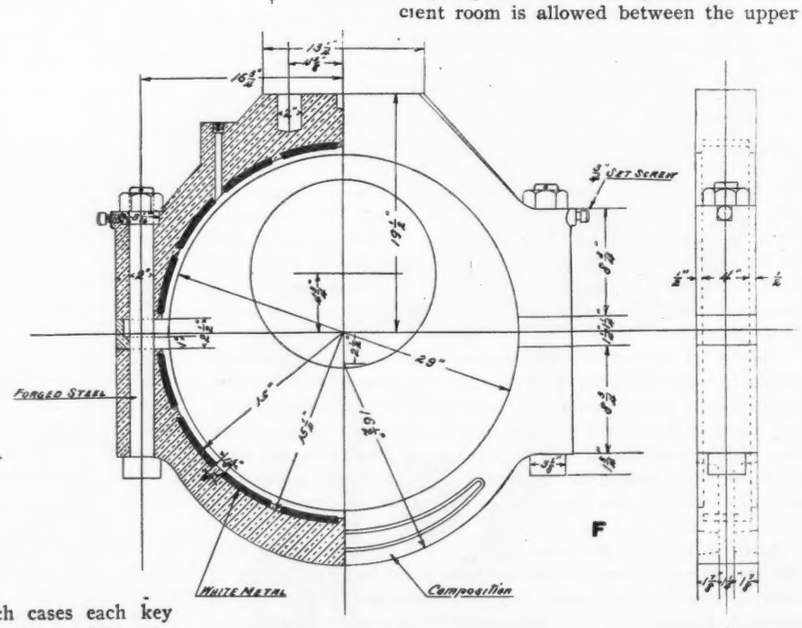
The diameter of the sheave should be made as small as possible to lessen peripheral speed. External diameter of sheave equals 1.2 (diameter of shaft + throw of eccentric). The width should be such as to give the pressure per square inch noted above. The diameter of eccentric sheave bolts should be such as to give a tensile strain of not over 4,200 pounds per square inch at bottom of thread for good steel. Fig. E shows eccentric sheave of a 5,000 indicated horse-power engine.



The strap of small engines are usually of cast iron or composition. Those for large engines are made of composition or cast steel; all lined with white metal generously grooved for oil. By composition is meant a bronze of about the following proportions: Copper, 88 per cent.; tin, 10 per cent., and zinc, 2 per cent. These straps should be thicker at the middle than at the ends. A thick liner with some thin ones should be inserted between the two halves, same tension on bolts in strap as in sheave. This is also the same for bolts in valve stem cap and those joining the eccentric in Fig. E.

Eccentric Rods.

The eccentric rods should be made as long as possible, care being taken that sufficient room is allowed between the upper end of the valve stem guide and the chest to allow of the valve stem stuffing box being replaced. These rods are usually slightly tapered about 3-16 of an inch per foot on a diameter. The diameter is found by same formula as for connecting rods, the constant being 21 for the mean diameter, taking the length as the diameter from center of link block to end of eccentric rod. The thickness of tee piece at end of rod equals 1.2 × diameter of bolts in same. Center to center of bolts should be such as to allow of a socket wrench settling over the nuts by the side of the rod. The shape of yoke as shown in sketch is necessary, as it must be free from all tendency to spring. The area of each end of yoke under the tee-piece should be from 75 to 80 per cent. of the area of the upper end of eccentric rod.



The pressure per square inch on the eccentric rod pin varies in medium and large engines from 800 to 1,000 pounds per square inch, and from 500 to 800 on small engines. The boxes shown in Fig. G are the two best styles, and the ones that are most extensively used. As there are four cap bolts to carry the same load as is taken by the two bolts at the butt end of the rod, they are necessarily smaller, and it is best not to allow so much strain per square inch on these small bolts. Allow them from 3,000 to 3,500 pounds per square inch.

As regards the forging of these rods, they should be most carefully made of good, sound material, either of wrought iron or steel, and of circular section, as experience has shown that, on the whole, the rod of circular section is preferable to the square section.

There are three classes of links, the open or slotted link, the solid bar link and the double bar link, the latter being the form now in general use. The link should be of generous size, thus giving ample strength and stiffness. The curvature of the link is swept with a radius equal to distance from center of link block to center of eccentric, and the distance from center to center of eccentric rod pins should be 2.8 × throw of eccentric. This center distance may be raised somewhat to suit the exigencies of the case. The following proportions will be found very suitable, the unit D being the diameter of the valve stem at the nut:

Depth of bar, 1.375 D + .75 inch.

Thickness of bar, 1.55 D + .15 inch.

Length of sliding block, 3.75 to 4 D.

Diameter eccentric rod pin, .9 D + .5 inch.

Length eccentric rod pin, .8 D .4 inch.

Diameter of suspension rod pins, .65 × diameter eccentric rod pin.

Length of suspension rod pins, .75 × length eccentric rod pin.

For engines of from 3,000 to 6,000 indicated horse-power the pressure on valve stem pin varies from 800 to 1,000 pounds per square inch; smaller engines from 550 to 800.

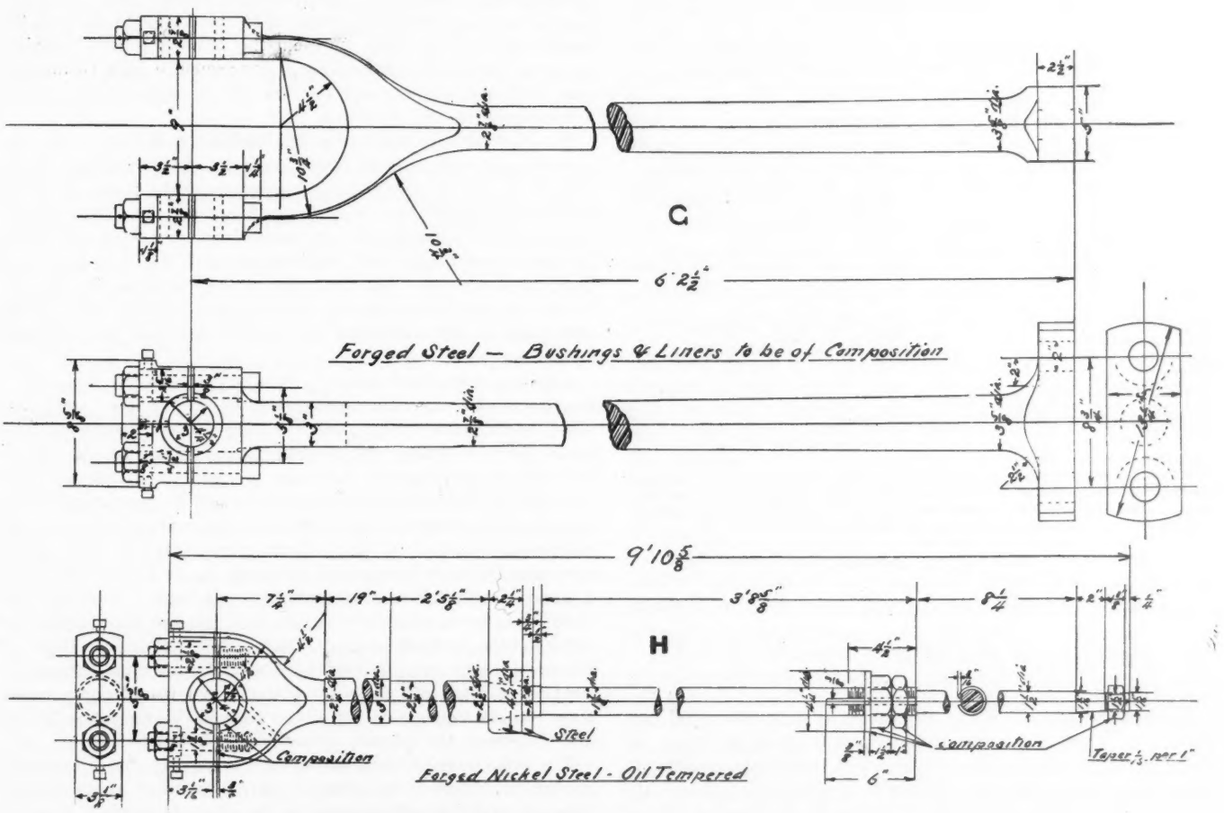
All the pins should be thoroughly case-hardened, whether the links are of wrought iron or steel. In all government work the pins are forged with the links, and this is by far the better job, although quite expensive. In merchant work they are usually forced in on a very slight taper. The taper seems preferable, although many designers make them parallel.

The United States Government requires the link to be divided into ten equal divisions and marked; 0 being the position when in mid gear, and 10 the position when in full gear.

Valve Stems.

The valve stem shown in Fig. H is typical of the modern style. It is usually made of steel. The diameter of the stem at the nut should be such as to give a tensile strain at root of thread of not over 4,000 pounds per square inch. The nuts should be composition, so that they will not stick fast; the tapered portion of stem to be 3 inches in 12 inches taper on a diameter. That portion of the stem from the valve to the center of the pin should have a constant of 21 by the formula for piston rods. It is usually more than that, as the stem becomes necessarily increased in diameter because of the taper and shoulder, so that if the correct size nut is found, the rest of the stem will be of ample size.

The area of tap bolts at root of thread should be equivalent to area of valve stem at nut. The valve stems are usually of the same diameter for all cylinders and interchangeable when possible. All valve stems are fitted with guides as close to the link as possible, with a length of from two and a half to three times diameter of stem in guide. The guide usually consists of a cast-iron or steel bracket bolted to the head of chest and lined with a composition bushing. The ends of the guide should overrun the shoulders on the valve stem, otherwise a lump will be worn on the rod very rapidly.



The stem, as shown in Fig. 4, is forged from one piece of steel, turned up, bushing inserted, and then cut and liners introduced.

A guide for the upper end of the stem is invariably used in government work, and it is also the best merchant practice for medium and large engines, the upper chest head having a cylindrical boss lined with composition and bored a loose fit for the upper end of the stem. It will be necessary to drill a hole connecting the bottom of this guide pocket with the chest to relieve the space of the water and air pressure.

* * *

The coal consumption of warships is a large item. It is stated that the English battleship "Powerful," when steaming 11½ knots, burns about 100 tons per day; but with one-half maximum power developed she burns 293 tons in one day. She carries the unusual quantity of 1,500 tons in her bunkers; or enough for twelve days at sea at moderate speed.

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AMERICAN MACHINERY IS THE TITLE OF THE FOREIGN EDITION OF THIS JOURNAL, WHICH IS PRINTED ON THIN PAPER AND COMPRISES ALL MATTER IN THE DOMESTIC EDITION. THESE TWO EDITIONS AGGREGATE THE LARGEST CIRCULATION OF ANY PUBLICATION IN THE MACHINERY TRADE.

MAY, 1898.

THE offices of MACHINERY and THE INDUSTRIAL PRESS have been removed to 9-15 Murray street, near Broadway, where we shall be glad to see all our friends.

* * *

The English press freely admit that in so far as the rapid production of work is concerned American machine tools are far ahead of those of English as well as of continental make. In some other important lines, however, we have not shown the same progressiveness, and one of these is in the development of the gas engine. The gas engine is a more efficient heat engine from a theoretical standpoint, than is the steam engine. Commercially it is very much more economical in small sizes, and even threatens to be at least a close second in large sizes at no distant day. Here, therefore, is a field for American enterprise, and in the last number of "The Engineering Magazine" Mr. George Richmond gives some interesting facts about the gas engine in America.

Mr. Richmond states that "until recently an account of American engines would have been merely a repetition of the description of European types, and not the most modern types at that." He attributes the slow growth of the industry in this country, first, to the lesser number of industries requiring a small amount of power; second, the greater cheapness of coal, together with the higher price of gas; and third, to the higher rate of interest rendering the investment in a high-priced gas engine a serious charge upon a business.

There are at present fully fifty concerns making gas engines in America, and Mr. Richmond shows by numerous illustrations that distinctively American types are appearing, chiefly enclosed vertical engines. He states that it is reasonably certain that in a short time high-grade gas engines will be sold in America at less per horse-power than in any country in the world. And this result will be brought about by factory methods of manufacture in quantities, and excellence of design and workmanship, rendering possible high rotative speeds—not by niggardliness in parts and proportions.

* * *

SUMMER SCHOOLS FOR MECHANICS.

The letter in another column by a machinist who has taken the summer course in experimental engineering at Cornell University, and who speaks in high commendation of this course, suggested to us that we enquire among different colleges as to whether summer courses were being offered in mechanical subjects suited to the need of machinists.

Accordingly, we addressed letters to representative institutions in both the East and West, including some of the smaller as well as the larger and more prominent ones. The replies showed that three of these are providing summer courses in mechanical engineering which are open to outsiders, while one is offering similar courses for the regular students only. The three schools mentioned are Cornell University, Ithaca, N. Y.; the Massachusetts Institute of Technology, Boston, Mass., and the Case School of Applied Science, Cleveland, O. Assuming the replies received to fairly represent the summer-school question, so far as mechanical instruction is concerned, it may be inferred that while but few such schools are already established, there is a movement in that direction.

One fact which is evident is that the time is at hand when machinists who want to push ahead must do some studying. Every year more and more of the good positions in the shops are being taken by men who have had more or less mechanical education. This kind of training is not everything, of course, for one's ability and other personal qualities count in the long run more than anything else. But the more of this training one has, the better will be his chances of success, particularly if the "ability and other personal qualities" are slightly deficient, as is the case with most of us.

Granted, then, that study is necessary, when and how can it best be carried on? Unquestionably, where one must study and work at the same time, during the long winter evenings and by means of the correspondence system or evening schools. There is a lack of completeness, however, in studies undertaken in this way, and if it were known that they could be supplemented by one or more summer courses of instruction at one of the magnificently equipped colleges where every possible appliance is provided for such instruction, it seems to us that it would be a great incentive for every ambitious mechanic. Summer is a time when business is likely to be dull, causing short hours for work, and everybody wants to take off more or less time for pleasure in any case. It would therefore be the most convenient time for a brief stay away from home, and would come at the right time to supplement the winter's work. So far as machinists are concerned, the summer school would be a good thing.

The successful prosecution of any course of study, however, requires thorough preparation in subjects upon which the course depends, and this will probably be the obstacle that will stand in the way of establishing summer schools and opening them freely to mechanics. The colleges will hesitate to admit applicants to classes, even of a summer school, when their presence, through inadequate preparation, would become a hindrance to the progress of the regular students. Nevertheless, we believe a little leniency in the matter would not hurt the colleges any and would do a great many young mechanics a great deal of good. It would not hurt the mechanical colleges to get into closer touch with the machine shop. It would not hurt their students, either, to be thrown in daily contact with practical machinists, who would doubtless impart enough practical information to those about them to more than repay for any extra assistance that they might require.

After all, it does not seem as though the matter of preparation need be a serious stumbling-block in the way of summer college courses for mechanics, and the assurances in this regard contained in the letter above referred to, bear us out in this statement. Summer courses are brief and of a special nature. They do not require the broad preparation that a full, regular course would demand, and we can think of no reason why preparation should be required in any subjects other than those absolutely necessary for a thorough understanding of the subject to be

studied. For example, if mechanical drawing were to be studied, arithmetic and plane geometry should cover the preparation; if experimental engineering, arithmetic and a little algebra ought to enable the student to keep up, although he might not understand the theory of beams or how to locate absolute zero—points, by the way, that no one is sure of.

By all means, let us have more summer schools, with doors wide open for all who have the ambition to attend and give promise of ability to learn. University extension work is a popular branch of education; let the extension take in the shop.

* * *

One of the big bubbles that has been riddled through and through and yet which seems to hold together largely, probably because it is one of the most gigantic schemes on record for getting something out of nothing, is the Keeley motor. In the last proceedings of the Engineers' Club of Philadelphia, Mr. E. A. Scott contributes a paper upon the subject. Mr. Keeley is an old man, over 70 years old, and works patiently in his laboratory. His secret is his stock in trade, and the possibility of it dying with him has aroused those who supplied him with funds. In their interests Mr. Scott visited the laboratory, where, however, he obtained only the vaguest kind of information and no satisfaction at all from the inventor, beyond that in his own mind he became convinced that compressed air was the secret motive power conveyed through supposed-to-be electric wires, but which were in reality minute tubes.

* * *

THE BARREL CALORIMETER.

An article or a book is often valuable, not only because of what it contains, but because of what it does not contain. As a good example of this, and for the benefit of the engineer readers of MACHINERY, we wish to refer to the article by Mr. Eldredge, in the last issue, upon the subject of steam calorimeters. He described three practical instruments for determining the amount of moisture in steam, but as far as we remember, this is the first comprehensive treatment of the subject that we have seen which did not include a description of the old-style barrel calorimeter.

In testing their steam plants, engineers want to know, with a reasonable degree of accuracy, how much water is being carried over with the steam; and until quite recently, certainly, the barrel calorimeter has been very generally used. Its apparent merit lies in its simplicity. All that is necessary is to get a barrel that will hold water, a pair of platform scales, a piece of hose-pipe, a steam gauge and a thermometer—things that can generally be found around any engine room. Cold water is run into the barrel, weighed, and its temperature taken; steam is then blown from the boiler or steam pipe, through the hose and into the barrel, until the water gets quite hot, when the temperature and weight are taken again, and by very simple calculations from these data the amount of moisture carried by the steam is determined.

Now, results not far from the truth can be obtained with a barrel calorimeter, provided the scales, gauge and thermometer are accurate and the operator understands his business. We venture to say, however, that the instruments are not very often accurate and that in nine times out of ten the operator does not understand his business well enough to get satisfactory results from them even if they were accurate.

In a test made with a barrel calorimeter, the figures of which we have at hand, there were 180 pounds of water at the temperature of 60.2 degrees, and after 7¼ pounds of steam at 73.8 pounds pressure had been run in and condensed the temperature became 103.6 degrees. From these the moisture figures out to have been 3.7 per cent. Suppose, however, that the weight of the steam had been taken to have been 7 pounds instead of 7¼ pounds, which might easily have been the case, since this weight is obtained by subtracting the readings of the scales before and after the steam is run in, and it is not easy to read platform scales with precision any way. The final result would then have been different by nearly 4 per cent.; and adding to this any error coming from the gauge, thermometer or from evaporation and radiation, and the extreme crudeness of the method and apparatus will be apparent.

* * *

It is stated that a certain quantity of illuminating gas used for running a gas engine which drives a dynamo will furnish nearly twice as much light as if burned in the ordinary way and about the same quantity as when burned in an incandescent mantel burner.

SEWING MACHINERY.—3.

A DESCRIPTION OF FOUR OF THE LEADING DEPARTMENTS OF THE SINGER WORKS—OTHER NOTES ABOUT SEWING MACHINE MANUFACTURE.

F W. BRADY.

There is some interesting history connected with the starting of the sewing machine industry. The actual facts are difficult to obtain, as a little prejudice always enters into this history in favor of the makers' individual machines. The writer, however, has endeavored to gather the facts as they are and to present them in an impartial light. It was found impossible to arrange the articles to present the different machines in chronological order and the Singer machine will be treated first.

The manufacture of the Singer machine was begun under great difficulties, and Mr. Isaac Singer was "backed up" by capital to the extent of forty dollars, and on the strength of this support, undertook to produce his first machine, which is not claimed to be "the original" sewing machine, but was one with certain improvements which it was believed would create a marketable machine, provided, as was said, the public could be induced to "throw the seamstresses out of employment." The first attempt was a flat failure, due more than anything to the inability to properly adjust the thread tensions. The stitch was made, which, by the way, was a lock-stitch, with shuttle thread, but it was loose and irregular. By the simple tightening of the upper thread, however, the machine was afterwards made a success.

A company was formed to make the machines, and to "fight it out" with the public and force the machines into the market, the latter presenting the greater difficulties, for, as a rule, inventors at that time did not consider any financial return possible, except from the sale of territorial rights to use their patents. To manufacture and sell seemed a hopeless task.

When Singer got a start, Elias Howe appeared on the scene claiming infringement and with a request for $25,000 "bonus" for his permission to allow the Singer Company to transact business. Then began the greatest litigation that the Patent Office, up to that date, had figured in. Howe not only troubled Singer, but others who at that time were also beginning to manufacture. The best legal talent obtainable was employed, and for several years the courts were busied with patent suits, the outcome of which was that Howe collected royalty from several of the early manufacturers.

Mechanical development is a queer thing. To-day the Howe machine (which was also placed in the market) has gone out of existence, while a few of his "infringers" have grown to a great size.

The Singer Manufacturing Company have at present three manufactories, one at Elizabethport, N. J., the exterior of which is familiar to many, where all of the metal work is done; another in Indiana, devoted solely to woodwork; a third near Glasgow, Scotland, to supply European trade.

The Elizabethport works will be briefly described as of considerable mechanical interest. They are shaped like a letter V, the sides of the V being buildings from one to five stories in height, and including between them the yard with its tracks, coal pockets, material, etc., etc. The only entrance is at the vertex of the V. Six engines, aggregating 1,100 horse power, furnish power to the whole plant. Views in four departments of the works are shown in the accompanying photographs, these particular views being selected as showing the individuality of sewing machine manufacture, especially in making the smaller parts.

The screw making is well worthy of note. All the machines are automatic to a greater or less degree, depending on the shape of the work.

Fig. 1 gives a view of one end of this department, where, it will be noted, as in every other view, the machines are placed just as close together as it is possible to crowd them and still allow room for operation. They are placed at a slight angle with the line of overhead shafting to allow the stock rod to clear the next machine in the row. Four new machines with all of the latest devices are shown in the foreground. They are not belted up, which shows those in the rear to a little better advantage. The belting to the machines gives the shop the aspect of an African jungle, and the mass of it almost takes away one's breath, when standing in a store room full of cases with not a wheel in sight

anywhere, the door is suddenly opened upon such an unexpected scene.

The subject of screw machinery should be better known than it is. Screw making is not a modern science, but to the majority the workings of the automatic screw machine are not understood. To those who do not know, it is sufficient to say that these machines are used for screws, studs, bushings, rollers, in fact all duplicate work requiring turning, threading, etc. The pieces are cut off the stock bar, and ejected from the machine when finished. Some of them slot the heads of the screws, some do not. The Singer screw list covers over eight hundred varieties, the smallest of which is cut 100 threads to the inch, and weighs a few grains, while the largest weighs in the neighborhood of a pound. All are made to gauge, and as to their interchangeability the writer can certify that of over fifty pieces calipered the variation in diameter was not over a quarter of a thousandth, although some of the tested pieces were purchased at one of the agencies some two years before the last ones were tested. This standard of constancy is necessary in all sewing machine making, and is attained in all of the high class machines. The output of the screw machine room is estimated at 250,000 pieces daily, each one being gauged and inspected before going to the stock room.

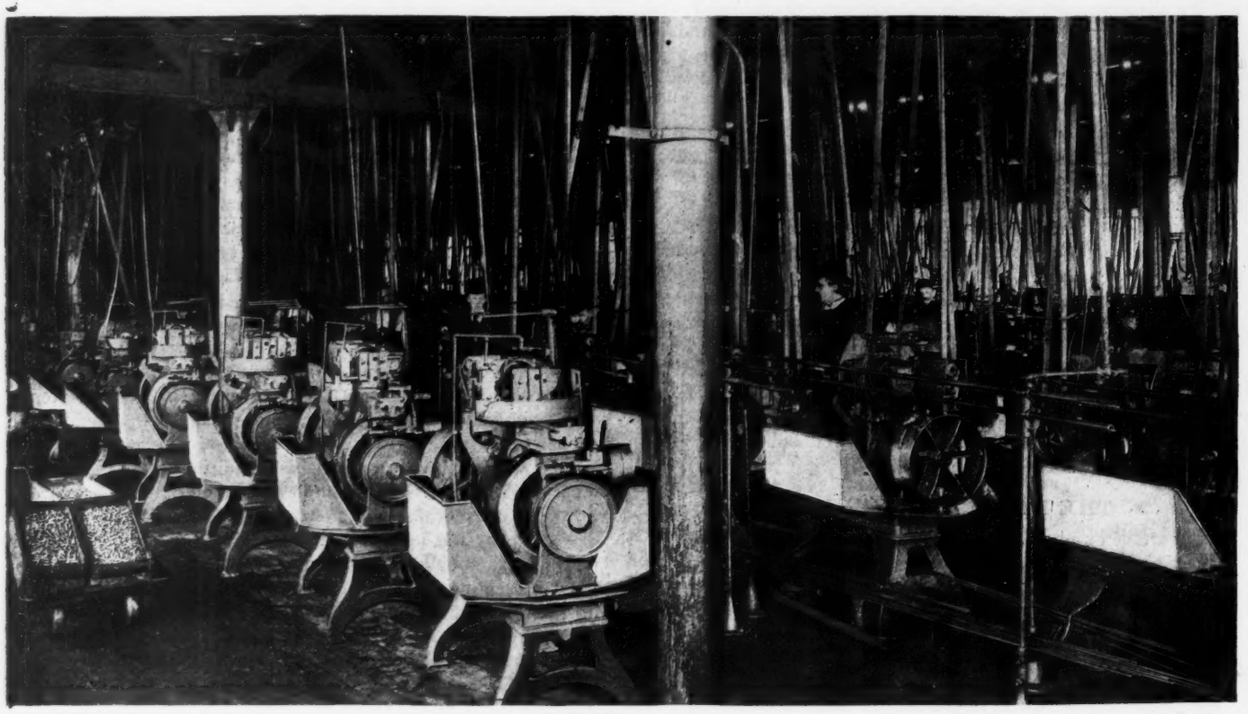


FIG. 1. SCREW-MAKING DEPARTMENT.

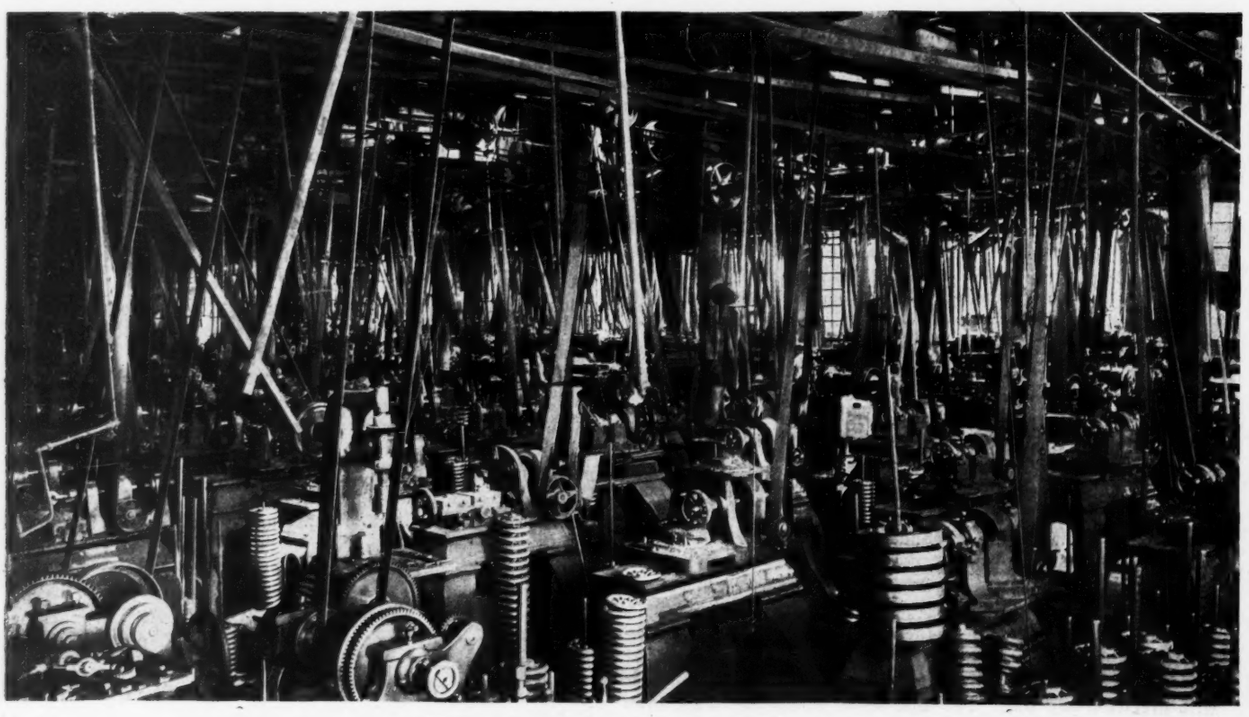


FIG. 2. WHEEL TURNING AND BORING.

Fig. 2 illustrates the operations of wheel-turning and boring, the machines being stubby lathes, in which the spindles are driven by worm and gear to get the right speed. The wheels are first bored and then slipped on over the spindle and held with a thumb nut, while the tool turns the rims, some flat, some crowned and others circular. The rims of these little fly-wheels come out

of the sand smooth, clean and very nearly round. So by chucking by the rim the central hole can be bored with little danger of spoiling the balance, although it is quite as necessary to have these little wheels in balance as their giant cousins on steam engines. Each wheel is carefully tested for this balance and for trueness of the belt groove.

The cam is cut with a master cam as a guide, and after finishing is hardened. It serves additionally as a collar between the face on the head and the line of the needle bar pitman.

A great variety of gears is produced in this department, all being of steel, and the majority of bevels and mitres are finished with one cut. The writer recollects one pair of bevels in which

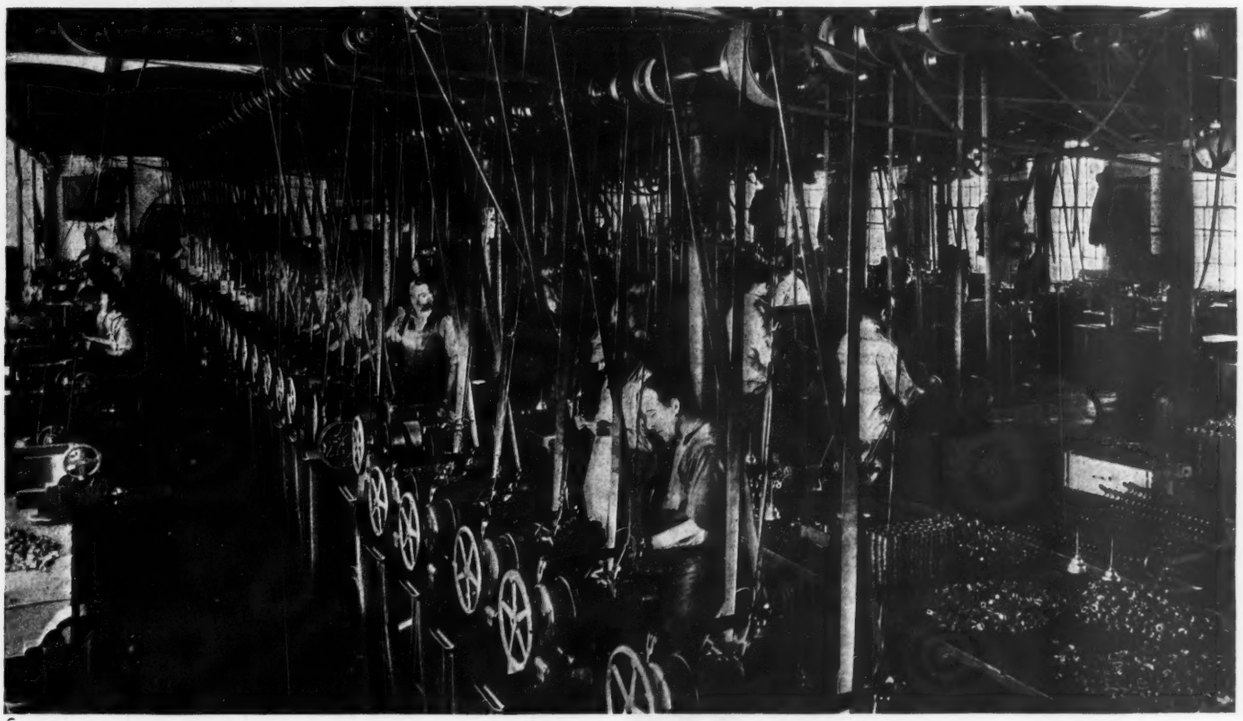


FIG. 3. CAM CUTTING.

FIG. 4. THE POLISHING ROOM.

An idea of cam cutting is given in Fig. 3, the machines nearest to view producing automatically the small cams, such as the one for operating the "take-up" (first article), and which also appears at the end of the upper shaft in Fig. 5. A pin is screwed into the end of this cam, which is accurately timed with reference to the cam and also in respect to the set screw holes, of which there are two, one of which goes into a "spot" on the upper shaft.

the tooth shape was very poor, and in hunting for an excuse for such a condition supposes that it is an old established standard with so many in actual use that it would be impossible to change it. Any small changes in a business of this magnitude involves an endless amount of confusion, and in this case would mean a new pair of gears each time one was ordered.

Something striking is presented in Fig. 4—a polishing room!

As generally found, this consists of a couple of wheels tucked away in one corner of a dingy end of the shop. But here is a large shop, employing between two and three hundred men, constantly engaged in the one operation. Many pieces are plated; all of the parts coming in contact with the thread are polished after the file has removed any sharp corners or edges.

The enormous quantities of dust are exhausted into tanks, leaving the atmosphere of the room comparatively clear.

The majority of machines of all makes are of the style shown in Fig. 5, having a base with an overhanging arm. At the bottom of this arm is a joint where it joins the base, and on this joint everything depends, since it not only serves as a tie to combine the two parts, but is a guide to all the first operations of drilling, boring and facing. On both arm and base this joint is finished first and is used as a basis for the work in subsequent jigs. All of these joints are milled on machines which are really rotary planers, built with a bearing for the spindle on each side of the bed. The clamps for holding the work are all fixed and tightened by hand screws. The cutter spindles run in good sized sliding bearings, each held down by a screw, like that used in a roll feed or a rolling mill. As used here, it appears light and weak, leading one to think that with heavy cuts and hard spotted castings it would not stand.

Files are not a much used article in sewing machine construction, much less so than would generally be expected. Their main duty is to smooth off edges left sharp or ragged by the cutting tools, and to "brighten up." These small pieces are worked so close that a slight slip of a file would spoil the work, and careful filing is a slow costly process.

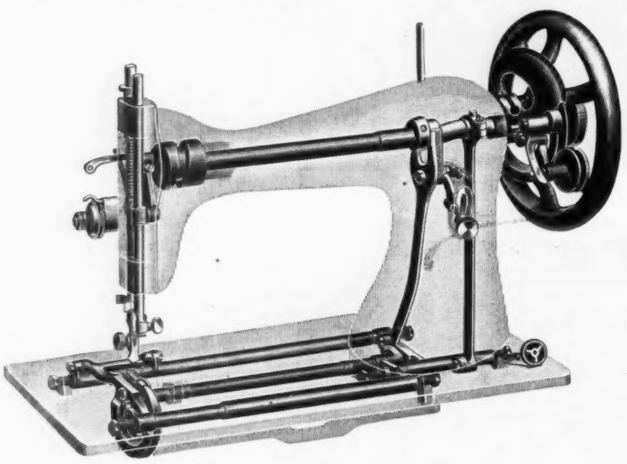


FIG. 5.

Some pretty specimens of sheet-metal work are to be seen, the bobbin and holder being among the large assortment. Small, flat springs are shaped in dies and tempered. About one thousand different styles of springs are made—flat, helical, spiral and conical-helical. All are expected to be nearly uniform in resistance, and are inspected for this quality.

In hardening both gas and fuel furnaces are used. The gas furnaces are employed for small springs and needles, the latter being made by each manufacturer to fit his individual machine. The making of the needles requires the most minute exactness and accuracy of the human eye, as the point grinding, straightening and eye punching are done by hand.

As every piece is finished and inspected before going to the stock room, and is supplied with spots for set screws and other marks for guidance in setting up, it is supposed that the machine will sew when it is assembled, and if it does not, the assembler is not supposed to "tinker" it. The general practice in almost every shop is to lay the machine aside until the defective piece can be located and replaced.

A record is kept of the test performance of each machine as it passes through the testing room, and this performance must include satisfactory stitching before the machine is allowed to pass.

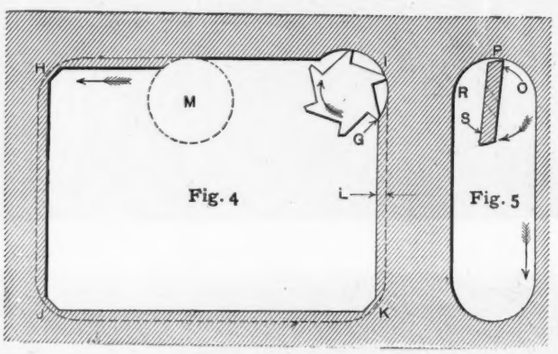
All of the Singer taps, dies, diameters, etc., are special; also the various parts cannot be made without special tools and appliances for holding the work and guiding these tools. This necessitates a large force in the tool room to supply and renew the stock of cutters and jigs, and this department, in addition to one for making and testing their standard gauges, is quite a plant in itself.

To give an idea of the wide range of work turned out at the Singer shops it may be said that one machine is made to stitch material up to three-quarters of an inch thick, especially belting, which necessitates an enormous needle and shuttle carrying a large amount of thread. It is built upon the principle of a modern punch with roll feed, except that the rolls have to be set with exactness to insure straight feeding. As a rule, in this heavy work the needle thread is lubricated to avoid the heating of the needle. The bed is eighteen feet long and weighs two and a half tons.

* * *

ANOTHER LESSON IN MILLING.

In my article on milling in the February number I explained how a slot or recess could be milled or enlarged without leaving a jog at the ends or corners by the use of a mill having only one or two teeth, which I believe is the most comprehensive and easiest way to avoid the trouble in the majority of cases. But that is not the only way it can be done when there is sufficient room in the slot or recess to permit each side of it to be finished separately. I think it is safe to say that with a two-toothed mill, an intelligent apprentice with any experience in milling, will enlarge a space like *H I J K*, as shown by the dotted lines in Fig. 4, and get better results than most journeymen do with the ordinary type of end mill shown.



Instead of beginning at *M* and milling towards *I*, with the mill rotating in the direction indicated by the arrow, let the mill revolve in the same direction, but begin at *M* and mill towards *H*. The tendency will be for the cutter to catch and break, but if the mill and other parts are rigid, and a weight or spring exerting sufficient power to take care of the blacklash is applied, there will be no trouble and no jog; because the mill crowds in towards the vacant space instead of being forced into the stock surrounding it when the additional teeth begin cutting at the corner. But it is seldom easy, and sometimes impossible, to secure conditions favorable to that method of working, and I prefer the two-toothed cutter. It may not be possible to mill so fast with a mill only having one point cutting at a time instead of several, but it is possible to secure greater accuracy.

Some might prefer to work into the corner at *I*, then set the cutter back to *H*, and mill across to *I*, finishing the side *H I* in the same way next, and so on around the space. A careful man can do a good job in that way if he knows how and takes pains with his work, but if I should attempt to explain how to go about it some one would probably spoil a piece of work trying to follow my instructions, so I advise the use of the two-toothed cutter on such work.

As indicated in the preceding, these notes are intended to refer only to the milling of recesses of sufficient width to permit each side to be finished separately.

In milling a slot of the same width as the diameter of the cutter, I can think of no practical way to overcome the effects of crowding when an ordinary end mill is used, and will advocate the use of the two-toothed cutter until I learn of something better.

"MILO."

[The above illustration is reprinted from the February number. It will be noted that the two-toothed mill described and recommended by "Milo" is similar to the one mentioned in this issue under "Among the Shops," and which was found at the Bertram shops at Dundas, Ont.—EDITOR.]

SHOP TALKS WITH YOUNG MECHANICS.—5.

THE CONSTRUCTION AND USE OF REAMERS.

W. H. VAN DERVOORT.

In order to produce holes as round, straight, smooth and uniform in diameter as is required in the construction of accurate machinery, a reamer must be used. As has been shown in a preceding article, the drill cannot be relied upon to produce holes possessing the above qualities.

A reamer is a sizing tool having two or more teeth either parallel or at an angle with each other, the latter forming what is known as a taper reamer. These teeth may be either straight or spiral; a spiral tooth producing a shearing cut, when a straight tooth gives a square cut.

As to their construction, reamers for producing parallel holes may be divided under two general heads—solid and adjustable. All taper reamers come under the solid class. A solid reamer is one having a shank and teeth made from a single piece of tool steel. The expansion reamer is a built-up tool, the usual form consisting of a shank and head, the head having suitable recesses in which are secured the cutting teeth. As adjustment to compensate for wear only is attempted, the amount of expansion is small.

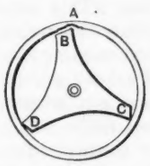


FIG 68.

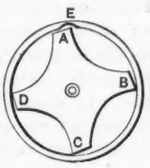


FIG. 69.

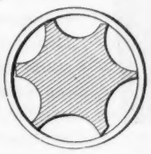


FIG. 70.

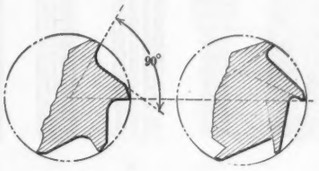


FIG. 71. FIG. 72.

The number of teeth, their form and spacing are the important considerations in the construction of this tool. Reamers having fewer than five teeth are not to be used where accurate cylindrical truth is desired. A reamer having three teeth cannot be depended upon to produce round holes, inasmuch as any irregularity in the hole being reamed affects the cutting of the tool. This is shown in Fig. 68, where a depression *A* exists in the drilled hole. When the tooth *B* comes to this point it drops in, thus decreasing the cutting of *C* and *D*, and produces a hole not round. The same effect to a lesser degree is produced in a reamer having four teeth, Fig. 69. When the cut is relieved at *A*, the pressure of the cut at *C* will crowd the tool toward *E*. Since the pressure of cut at *B* and *D* balance each other, any decrease of cut at *C* causes an increase at *D*, and *B* and *C* will overbalance *D*, the body of the reamer moving an appreciable distance toward *E*. With five or more teeth this effect practically disappears. The more cutting edges, the more smoothly will the reamer work. The construction of the adjustable reamers does not admit of as many teeth as can be formed on a solid reamer, yet the advantage of adjustability to a certain extent offsets this.

Reamers having an even number of teeth equally spaced do not produce as good results as those having an odd number of teeth. In the former, the teeth fall opposite each other, causing greater tendencies to vibration, and in the case of reaming irregular holes, the greatest cut will be carried on two opposite teeth; but with an odd number of teeth, the greatest cut must be carried on at least three teeth.

Reamers having an even number of teeth but irregularly spaced are very extensively made. A cross-section of such a tool is shown in Fig. 70. The effect is practically the same as having an odd number of teeth.

The form of tooth usually employed is shown in Fig. 71. The front face is on a radial line, the flute being well filleted at the root. If an angle of rake is given the tooth, as shown in Fig. 72, and specially so if the fillet at root is cut away, the tooth will spring out under the cut, producing an oversize hole.

The grinding of the clearance on top of the tooth is an important point in the construction of a reamer. The clearance should be sufficient to properly relieve the cutting edge. If too great clearance is given, the tooth will be weak and chatter in the work. As frequently produced, the cleared surface is slightly concave, the amount depending on the diameter of the emery wheel used in grinding it. As a plain surface is desirable, a wheel of large diameter which gives approximately such a surface, should be employed.

The angle of clearance will depend on the distance the axis of the emery wheel is set back of the axis of the reamer, as shown in Fig. 73. In no case must the wheel come in contact with the front face of the tooth being ground or the one next behind, and the guiding finger which steadies the reamer must always bear against the front face of the tooth being ground. When the diameter of the reamer is large and the pitch of the teeth so small that the necessary clearance cannot be given except by using too small an emery wheel, the wheel can be mounted on an axis at a considerable angle with the axis of the reamer, as shown in Fig. 74. This produces a plane surface. The wheel must be so placed as to cut its entire width, otherwise it will be grooved and the cutting edges of the tooth rounded off.

A hand reamer is a tool for hand use; while a chucking reamer is operated in a machine. Fig. 75 illustrates a standard solid hand reamer. In its manufacture, the stock is first cut to length and then turned to a diameter about 1-64 inch over finish size. The flutes and square on the end of shank are next cut by milling processes. Tempering is the next operation, from which it usually comes warped to a greater or less extent. After straightening, the centers are lapped out and the reamer ground in a grinding machine to a correct diameter and cylindrically true. All standard reamers are made .0005 of an inch over size. This is because a new reamer, before being used, should have its cutting edges stoned slightly, which will just about bring it down to exact diameter. If this is not done, the edges will give down a little on the first few holes reamed; so that if the reamer were made to exact diameter it would fall below size too quickly. The shank is usually ground about .001 of an inch smaller than the fluted portion, and in its use serves as a gauge to indicate when the reamer has fallen, through wear, below .001 of an inch under size. The shank should not be marred in any way, as in that case the purpose for which it was so carefully brought to size is lost, and in cases where the reamer is passed through the work, damage to the hole is apt to result. The last operation previous to grinding the clearance and final inspection in the manufacture of a reamer is the buffing out of the flutes. This is done by passing them under a small vulcanized emery wheel, which has first been trued to the exact outline of the flute.

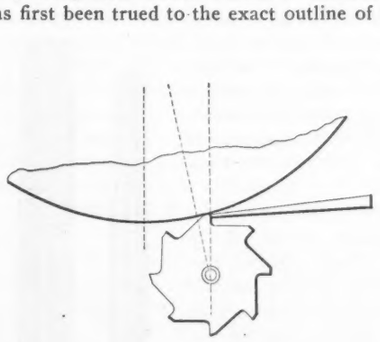


FIG. 73.

FIG. 74.

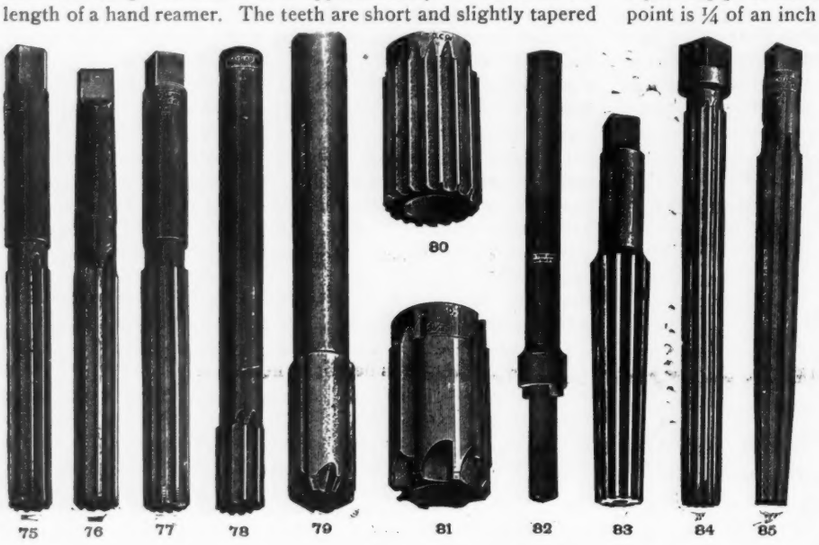
The hand reamers are regularly made in two lengths; what is known as the short reamer being considerbly shorter both in the flute and shank than the regular or jobber's reamer. The diameter of the point is about 1-64 of an inch under size, the tool tapering to exact diameter at about one-fourth the length of the tooth from the point. The balance of the teeth are ground nearly parallel, the diameter at the shank end being from .0005 to .00075 of an inch small. This slight taper counteracts the tendency that all reamers have to ream a hole slightly over size at the top, which is due to the tool remaining longer in contact with the wall of the hole at the top than at the bottom. The limit of error allowed in their manufacture does not exceed .00025 of an inch.

When, for the parallel shank of the hand reamer, a taper shank is substituted, as shown in Fig. 76, the reamer becomes adapted to use in a drill press or other machine. The form and length of flute is the same as for the regular hand reamer, except at the point, where the teeth instead of tapering for one-fourth of the length of the flute, run parallel to the point. This form is used because the reamer cuts easier and faster, and as it is

steadied by the spindle, no difficulty is experienced in starting it true.

In Fig. 77 is shown what is known as the Millers self-feeding hand reamer. The point of this reamer is provided with teeth similar to tap teeth, which draw the tool forward as it is rotated, thus giving it a uniform feed through the work.

Fig. 78 illustrates a fluted chucking reamer with parallel shank. The total length of this tool is approximately the same as the length of a hand reamer. The teeth are short and slightly tapered at the point, which facilitates starting when used against the dead center of a lathe. It is also provided with a taper shank, in which case the teeth are made parallel to the point.



The rose chucking reamer, Fig. 79, is of the same length and provided with the same forms of shank as a fluted chucking reamer. The head is ground cylindrical with cutting teeth on the end. The circular flutes do not form cutting edges, their office being to carry the lubricants to the point of the tool. The head is given only a slight clearance in its length. The result is that holes produced with the rose reamer are usually round and straight, but not so smooth as those found by longer cutting edges. The lack of clearance in this tool makes it unsuitable for reaming deep holes, as a small amount of heat causes it to expand an amount sufficient to bind in the hole reamed.

The shell reamers, Figs. 80 and 81, are chucking or rose reamer heads, having round central holes usually tapered, the taper used being ⅛ of an inch per foot for the reception of the arbor shown in Fig. 82. A rectangular slot or key-way is milled across the shank end to receive the cross key of the arbor; several sizes of reamers are made to fit each size of shank. The first cost of a set of shell reamers and arbors is but little less than that of a set of regular rose or fluted chucking reamers.

Fig. 83 illustrates a Morse standard taper reamer, which is made in six regular sizes, from No. 1 to No. 6, inclusive. The taper is approximately ⅝ of an inch per foot. (The exact amount of each size was given in the talk on drills.) Reamers for the Brown & Sharp taper are the same form as for the Morse, the taper being ½ inch per foot for all sizes.

Fig. 84 shows a reamer largely used on locomotive work. The taper is slight, being 3-32 of an inch per foot of length. They are usually given a steeper taper at the point to facilitate starting, and are regularly made, by thirty-seconds, from ¼ to 1½ inches in diameter. The diameter is measured at the small end of the long taper, not the point.

In Fig. 85 we have a bridge builder's standard taper reamer, used in bridge and boiler work for bringing fair rivet holes that come partly blind. They are made for the various sizes of rivets used from 9-16 of an inch to 1 1-16 inches, the diameter being measured at the large end of the taper. Seven inches is the usual length of flutes used on all sizes, two inches of the point being on a steeper taper. The diameter for the small end of the 5-inch taper is 3-32 of an inch smaller than at the shank end, and the point is ¼ of an inch smaller than the shank end.

A standard taper pin reamer is shown in Fig. 86, the taper of which is ¼ of an inch per foot. They run from No. 0 to No. 13 in sizes, the smallest being ⅛ of an inch at the small end, and the largest approximately 1 inch. The point of each reamer will enter in a hole reamed by the next size smaller.

When a solid reamer, through wear, falls below standard size an amount greater than the allowable limit of error, it can be brought up to standard size again only by drawing the temper, upsetting the teeth by driving against their front faces, retempering and regrinding. This is an expensive and unsatisfactory operation. It will usually be found best to grind it to about .005 under size and use it for a sizing reamer. In some cases it is possible to grind them to the next thirty-second or even sixteenth size smaller. This makes the teeth wide on top; but if the clearance is properly ground, the reamer will work well. In such cases, care must be taken to obliterate the original size stamp, and replace with a new one to avoid errors.

It must not be inferred that a properly made solid reamer falls quickly below size when properly used. Its life as a standard tool depends upon the hardness of the metal reamed and the amount of cut it is required to take. It must be remembered that the standard reamer is a finishing tool, and must, as such, be capable of reaming a great many holes to practically the same diameter. To accomplish this the cut must be very light, never exceeding 1-64 of an inch, and preferably not more than .005 to .01 of an inch. When great uniformity is required, a sizing reamer .005 to .007 of an inch under size, usually operated by power, is first passed through the holes. This leaves a true hole and equal cut for the finishing hand reamer. When so used in soft cast iron, a standard hand reamer will finish holes aggregating in depth 5,000 to 10,000 inches before falling appreciably below size.

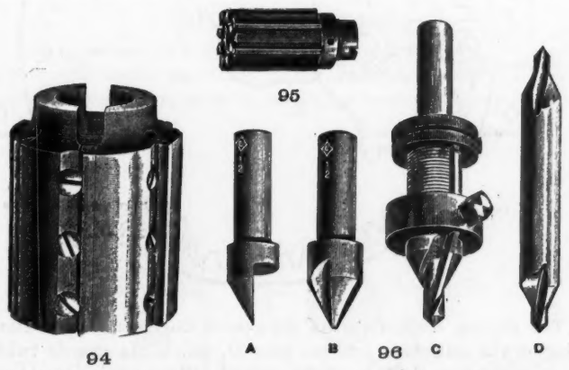
There are numerous adjustable reamers on the market. Fig. 87 shows a reamer in which a screw in the point forces a tapered plug into the tapered hole in the center of the tool which expands the teeth, the slots parallel to the teeth and extending through to the bore, allowing the necessary amount of spring. It is evident that the teeth expand most at the center, but as the amount of expansion necessary to preserve standard diameter is very small, this will have little effect on the working of the tool. The cylindrical portion of the point is called the "guide" or the "pilot" point, and is usually ground .005 to .007 of an inch under size, which of course limits the amount of stock left for finishing. This reamer is made from ⅜ of an inch to 2½ inches in diameter.

Another form of adjustable blade reamer is illustrated in Fig. 88. It consists of suitable number of blades or chasers, fitting milled slots and abutting against a ground tapered plug in the center of the head, the end of which is threaded into the shank. By screwing the plug in, the blades are forced out the required amount, and when adjusted, the dished-head nut engages the beveled ends of the blades, holding them firmly in position. These reamers have an adjustment of about 1-32 of an inch, and are regularly made in sizes from ¾ of an inch to 2 inches.

The reamer shown in Fig. 89 consists of a head having milled slots slightly dovetailed, in which are closely fitted blades resting on small tapered wedges. To enlarge the diameter of these reamers, the wedges are driven toward the shank of the tool, thus forcing the blades out. This reamer is made in shell or hand pattern from ¾ of an inch to 4 inches in diameter.

The adjustable reamer shown in Fig. 90 has a series of dovetailed grooves for holding the blades, which fit accurately these grooves. The grooves are deep at the point and tapered to about one-half the depth at the shank end. The bottom of the blades is tapered to fit this groove, and the reamer is enlarged by driving the blades toward the shank. The reamer is also made in shell pattern from 2 inches to 4 inches in diameter, with straight or tapered holes.

The expansion reamer shown in Fig. 91 is an exception to the general rule, as it is expanded from size to size, twelve reamers making all sizes from ⅝ of an inch to 4⅛ inches. Tools of this character cannot be relied upon for exact settings, and are therefore not suitable for work requiring high degrees of accuracy. It is difficult to set the blades of an adjustable reamer out equally, especially in those where each blade is set separately. The only safe way is to set them out somewhat more than necessary and grind them down to standard size. The blades of adjustable reamers are usually unequally spaced. Other forms of adjustable reamers are shown in Figs. 94 and 95.



When spiral flutes are used, as shown in Fig. 92, they are cut left hand, as a right-hand spiral would cause the teeth to worm into the cut too rapidly. In using the reamer it should be turned continually forward, both on the advance and on the withdrawal; turning it backward while in the work is quite apt to injure the tool, due largely to small particles of cuttings lodging between the clearance surfaces and the wall of the hole. In hand reaming the tool can usually be passed through the work. Oil should be used freely in reaming steel or wrought iron. Cast iron and brass are usually reamed dry. A small amount of oil will, however, frequently improve the quality of the work in these metals.

The preparation of the holes for taper reaming is of great importance. As a reamer should not remove all the metal that would be left if a drill the size of the point of the reamer were passed through the work, several drills of different diameters may be used, producing a stepped hole, as shown in Fig. 97. If the work is done in a lathe, the taper attachment or compound rest can be advantageously used, using a boring tool to enlarge the drilled hole. If the lathe has neither of these attachments, the hole can be stepped out, as in Fig. 97, with the boring tool. A roughing reamer, Fig. 93 is well suited to the preparation of a hole to be taper reamed.

When reaming either taper or parallel in a lathe, the work rotating and the reamer held against the dead center, true work must not be expected, if the reamer is allowed to follow directly after the drill, as it is practically impossible to so start a drill that the drilled hole will be exactly concentric to the axis of the lathe spindle. This will cause the point of the reamer to move in a small circle around the center of rotation, producing a tapered instead of a parallel hole. If true holes are required, the drill used should be enough smaller than the reamer to allow for the trueing of the hole with the boring tool, which will bring it concentric with the axis of rotation before the reamer finishes it to exact diameter.

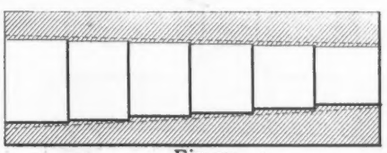


Fig. 97

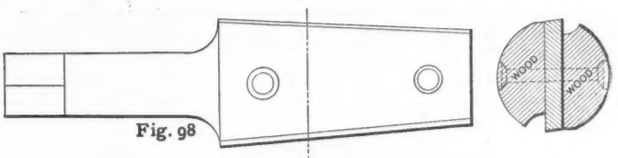


Fig. 98

When the reamer is used in a drill press, correct results will be obtained only when the hole reamed is exactly concentric with the drill spindle, otherwise the reamer will be held against one side of the hole, making it elliptical in cross-section at the top. These difficulties in producing perfect reamed holes by machine-driven reamers, compels the extensive use of the hand reamers, the holes having been previously sized with an undersize reamer.

A simple form of reamer shown in Fig. 98 will frequently obviate the expense of a special reamer when only a few holes are to be sized. The tool can be made at slight expense, and when carefully constructed will produce very good results.

The reamers used for reaming center bearings in work to be machined between centers are shown in Fig. 96. *A* is the "old Hartford" reamer with one cutting edge. It cannot be relied upon to produce a true conical hole. A "new Hartford" center reamer is shown at *B*. It has three cutting edges, and will produce a true hole. These reamers are intended to follow a small drilled center hole, and are made with 60-degree, 72-degree and 82-degree angles, 60 degrees being the standard. They are also made in several sizes from ¼ to ¾ of an inch, largest cutting diameters. A form of combination center reamer and drill, in which the drill and reamer blades are held in a suitable shank, is shown at *C*. At *D* is shown a combination center drill and reamer that has come into general use. It is admirably adapted to its work, being efficient, simple and inexpensive. The drill steadies the reamer, which makes it cut smoother, and insures its coming central with the drilled hole. This is of special value when the surface of the work is uneven. The countersink is similar to the center reamer, having, however, a greater number of teeth.

* * *

The "one-piece" 8-inch Gatling gun lately made for Dr. Richard J. Gatling by the Otis Steel Company, of Cleveland, O., is intended to be a wide departure from the present method of making guns of large caliber by the "built-up" process. While the details are withheld from the public, the general result of Dr. Gatling's late experiments seems to be the discovery of an alloy of steel with a tensile strength of 108,000 pounds to the square inch. This steel is cast into the intended form, and the steel surrounding the bore is then forged by a special process and thus made denser. After the completion of this process the gun is rifled, and is then ready for test or service. The advantages claimed are great comparative cheapness of construction for guns of all calibers, and a great saving of time of construction. The new gun will soon be tested at Sandy Hook.

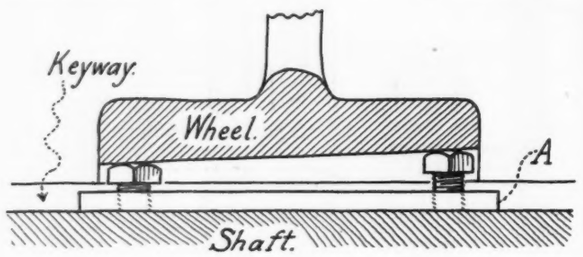
WHAT MECHANICS THINK.

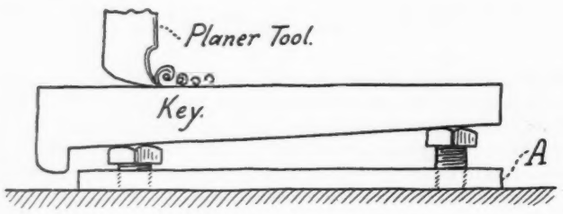
A DEPARTMENT FOR THE EXPRESSION OF PRACTICAL IDEAS OF INTEREST, TECHNICAL OR OTHERWISE.

Write on one side of the paper only, and when sketches are necessary, send them. No matter how rough the sketches may be, we will see that they are properly reproduced.

TO FIT A LARGE TAPER KEY.

To fit a key for large wheels is a nice job, especially when it comes to planing just the right taper. The accompanying sketches show a convenient and accurate method for getting the taper by the use of the simple piece shown in both views at *A*. This piece is of flat steel, tapped at each end for screws, as shown, and accurately planed on the bottom. The wheel having been placed in position on the shaft with the key-ways together, the strip *A* is laid in the key-way in the shaft, and the screws are adjusted against the bottom of the key-way in the wheel, as indicated in the upper view. Piece *A* is then slipped out and laid in the bottom of the shaper chuck, or on parallels in the bottom of the chuck. The key, having been roughed out and three sides finished, is then placed on top of the screw heads and the last side finished to the correct taper without going to the trouble of measuring. The key is shown in this position in the second view.

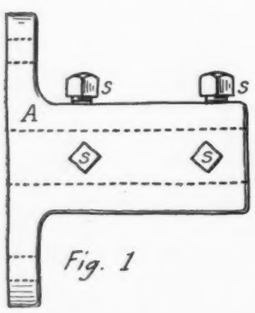


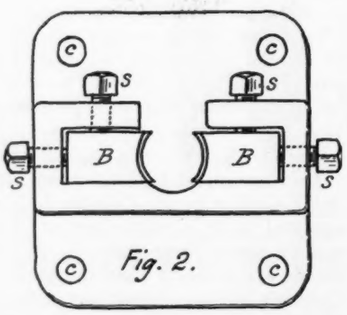


Salem, O. C. F. A.

CHUCK FOR HOLDING SPLIT NUTS.

It being necessary to make a lot of brass split nuts for some screw jacks which have this feature to allow of rapid lowering of screw when the load is not on, a chuck for holding the halves while cutting the internal threads was made, as shown in the two views Nos. 1 and 2. It consists of a casting *A*, which was planed off on the end so as to be bolted directly to the face plate of the lathe, being held by bolts through the cored holes *C C C C*.





The internal part was machined out on a slotter, and eight set screws *S* were provided to hold the brass halves *B*, as shown.

The side *D* was left open to provide for inspection of the work, and to allow the chips to fall out freely as cut away.

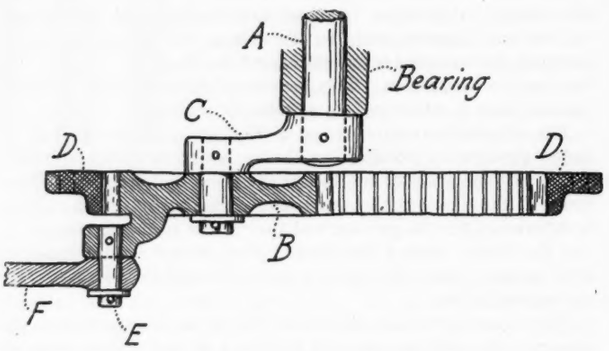
The tool used for cutting the threads, which were of the half-V form, was a bar of 1½-inch steel turned down to about 1⅜ inches for 7 inches of its length and bolted through the square part in place of the ordinary tool post. This bar was further supported by a hook clamp engaged with the under side of the carriage between the ways and coming up over its back end.

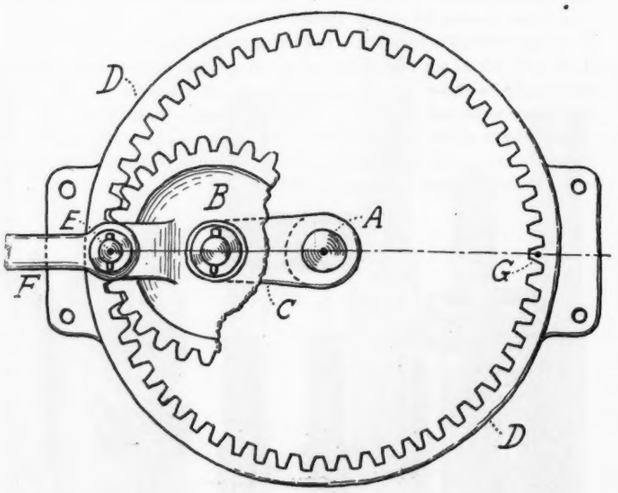
A chuck similar to this would be useful for chasing the split nuts used in lathes for screw cutting.

Corning, N. Y. FRED E. ROGERS.

A STRAIGHT-LINE MOTION.

Perhaps the following will interest some of your readers, although it is by no means new—few mechanical motions are. A friend sketched it out for me several years ago, and I have mentioned it to quite a number since, and none of them seem to have heard of it before.





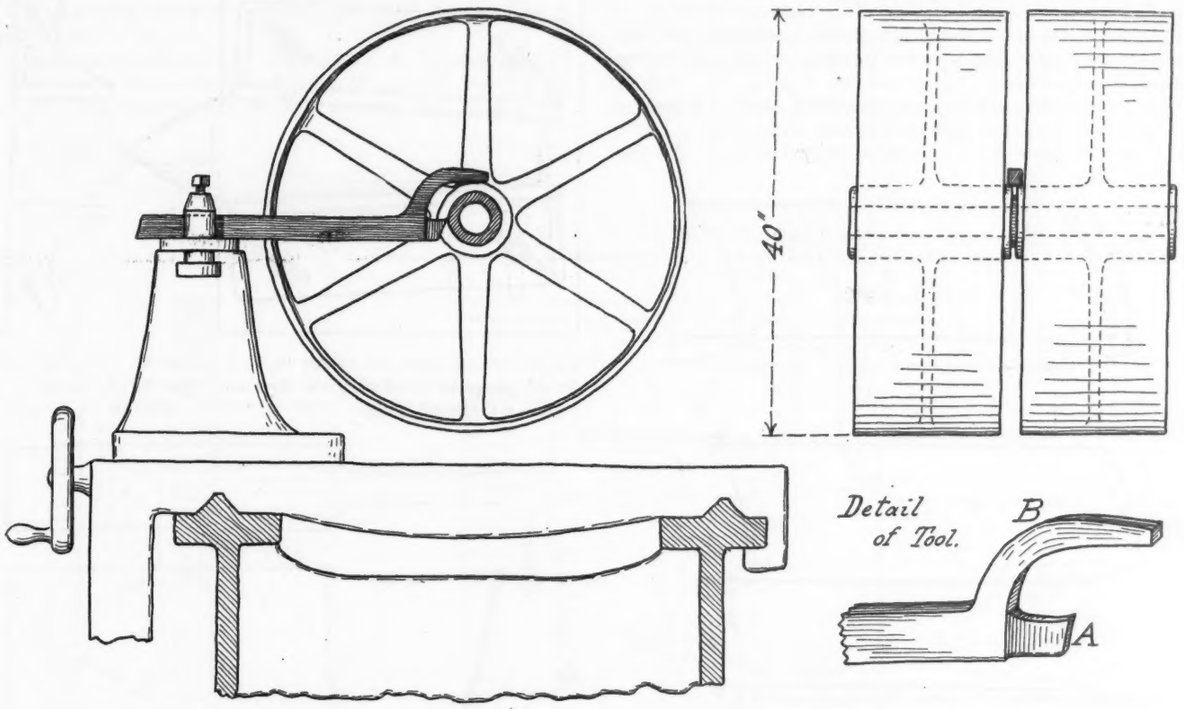
The driving shaft *A* carries the gear *B* on a crank *C*; *B* running in the stationary internal gear *D*, which has exactly twice as many teeth as *B*. Now, if the center of the pin *E* is exactly on the pitch line of *B*, and *A* is revolved, *F* will move in a direct line *E A G* across the center of the driving shaft to the opposite side of the internal gear and back again at each revolution of *A*.

There are cheaper ways to obtain the same result without a connecting rod, but I am told that this was actually used on a printing press, and gave the best satisfaction. I have never seen it in use. MILO.

[This motion has been used on German printing presses, and we believe by at least one American builder of presses. It is more practical than might at first appear. It has the advantage of giving a long, gradually increasing and decreasing motion, with a very short crank, and without the use of a connecting-rod or a slotted cross-head. It can therefore be used where there would not be room for the former or there would be mechanical objections to the latter.—Ed.]

A LONG REACH CUTTING-OFF TOOL.

A double-arm pulley was sent into the shop one day from an up-country sawmill, and the fellow who brought it said, "Cut this in two in the middle, so I can have two pulleys." The pulley was 40 inches in diameter, 30 inches face, 2½ hole, and the diameter of hub was about 7 inches; so it was out of the



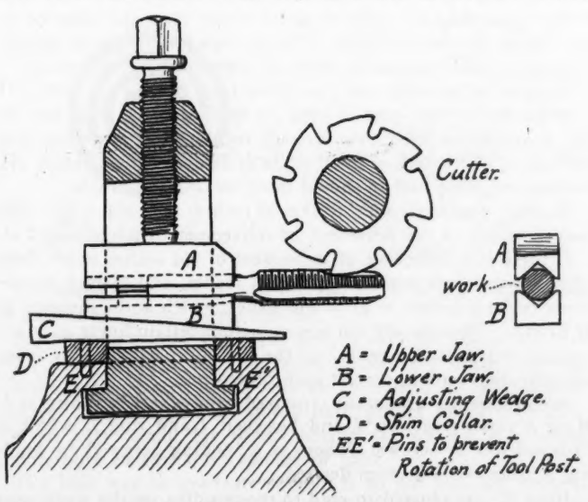
question trying to cut the hub open from the inside of hole with a boring tool. Here is the way the man did it who was assigned the job: He first took a ¼-inch cut-off tool and cut 1 inch out of the rim, then made a tool like sketch; the cutting part was like an ordinary cut-off tool long enough to reach through the hub, and the part *B* larger and longer, so that when *A* commenced to cut, *B* would reach beyond the center of top of hub. It was then an easy matter to cut off the hub without having the tool jump and chatter.

B. F. GROUT.

East St. Johnsbury, Vt.

MILLING DEVICE.

The sketch shows a device, easily made and used in any lathe, which will enable the victim to groove taps, spline small shafts and do a surprising amount of similar work—when no milling



machine is handy—and experience proves good work may be done with it quite rapidly. An extended description is unnecessary, as any mechanic will see at a glance how it is used. The piece *D* is a collar which serves as a shim, and which has the pins *E E'* preventing movement while setting work. If the tool post is right for it, a simple straight piece can be driven into the slot in the tool post and used instead of the ring.

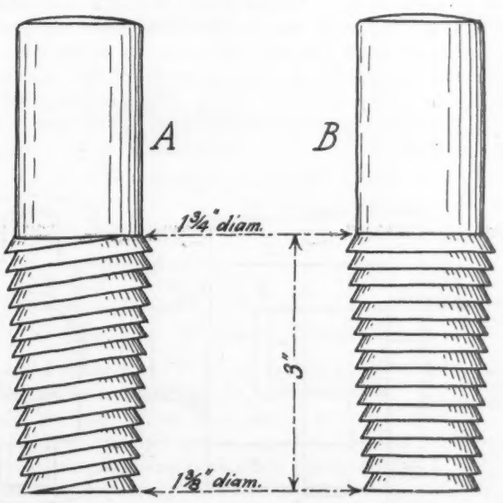
I always mark off the divisions on any work requiring more than one groove, for which purpose I have the side face of the large gear on the spindle of the lathe divided, and using a point in the tool-post set at the height of the centers, I can scratch off divisions quite lively. This is only for people who haven't machinery and, like Mr. B. F. Grout, in the February issue, don't want to turn away work.

JNO. T. HUME.

Merca, Pa.

CLEANING CORE HOLES.

Every foundryman has his own way of cleaning core holes of the thin scales of metal which frequently form around the inside of the holes at the surface of the casting. When a drift of the ordinary form is employed, it very often bursts the metal, especially if the core happens to be in a lug. The two sketches herewith illustrate two improved styles of drifts, made of hardened



steel, which, instead of wedging themselves in the core hole, clean it entirely of superfluous metal by cutting it away as the drift is driven in with no danger of bursting the metal.

Style *A* is easier to make, since the threads are cut similar to a screw thread, and works best in brass castings. Style *B* is a little more troublesome to make, as it necessitates the moving of the cutting tool for every thread, but it is much to be preferred and does best work in cast-iron castings. The taper of the drift

and number of threads to be cut are, of course, made proportional to the size of the hole for which the drift is to be used. The proportions of the drift shown in the given sketch give good results when cut with five threads per inch.

Hokendauqua, Pa. GEO. H. WALTHAM.

TWO KINKS.

Enclosed please find a sketch of a mould in which to cast soft, false jaws for a vise. The jaws can be made of lead, and are better than those of copper.

Figs. 1 and 2 represent the two parts of the mould. A piece of thin sheet iron 1-16 of an inch thick is bent in the form of Fig. 1, and a heavy strip about ¼ inch thick is riveted on at *a*. Another

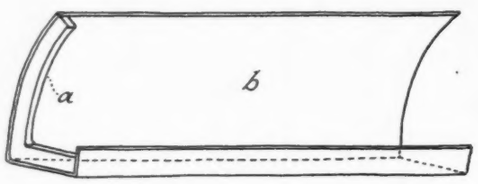


Fig. 1.

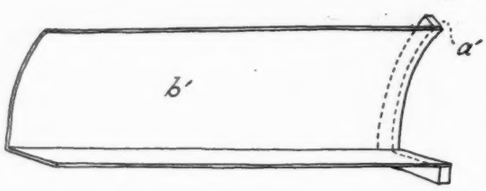


Fig. 2.

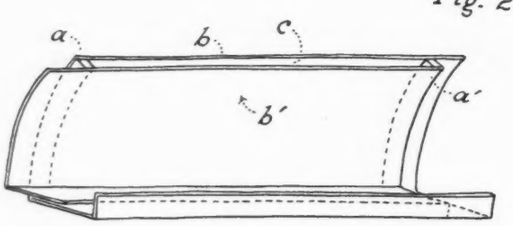
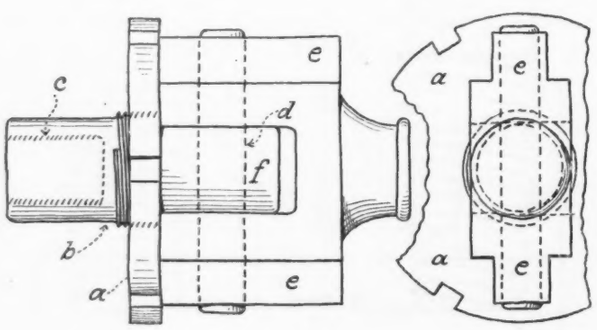


Fig. 3

piece of iron is bent in shape of Fig. 2, and ¼-inch strip of iron is riveted on at *a'*. Slide No. 2 on No. 1, as shown in Fig. 3, leaving an opening at *c*. Seal all cracks with clay and pour the metal in at *c*. The mold can then be taken apart, and you will have a piece of metal that will fit on the jaw of the vise. The moulds must be made longer than the width of the vise, and the pieces can be closed or opened wider, thus obtaining different widths. This kink came from Germany with a man who is working at our shop.

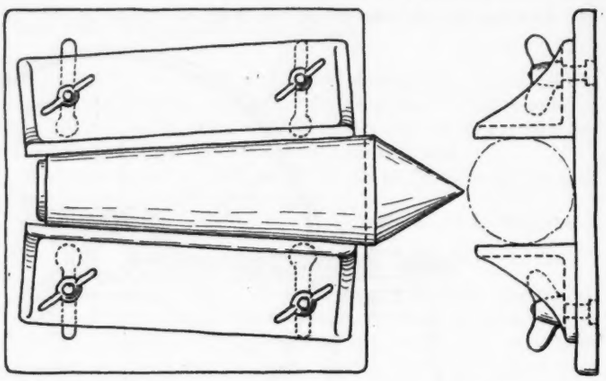


The next drawing represents a jig for crossheads. The end *c* is screwed on to the lathe spindle, the crosshead is pinned on the other end, and the flange *a* is screwed tight against the crosshead in order to keep it square. The crosshead is then central, and can be bored and tapped quicker and with greater ease and accuracy. G.

Burlington, Ia.

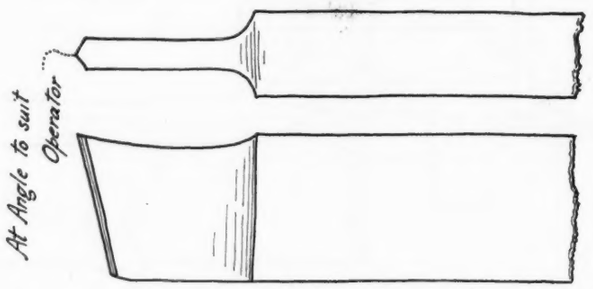
TWO MORE.

I herewith inclose a sketch of a taper gauge which I have made, and which is a handy thing. Sometimes a man has to make a center for a lathe away off from his work, and if he has



one of these gauges, all he has to do is to get an old center and set the gauge to it, which gives the exact taper for the work.

Indian Orchard, Mass. FRANK G. LILZA.



A reader at Syracuse, N. Y., sends in the above sketch, with the brief but sufficient explanation: "Here is a cutting-off tool that will cut off square."

A RIG FOR CUTTING SCROLLS—LATHE GRADUATIONS.

I send a sketch explanatory of a rig I have used for cutting small scroll screws where lathes with geared crossfeed are not to be had.

A piece of flat iron *A* is pivoted to the sliding block of a common taper attachment at *B*. At *C* bar *A* is connected to the cross-slide by a pin or screw, and at *D* a link *E* is connected to *A*. The opposite end of the link is pivoted to a rack *F*, which is in gear with a change gear on the stud of lathe. Rack *F* is guided in a trough (not shown), made of wood in this case, and fastened to the change gear swing frame. The carriage is brought up against a planer stop *G* clamped to front of lathe bed by C-clamp *M*.

Suppose we want to cut a scroll of four threads per inch. If a 16-pitch, 28-tooth gear is used on stud and stud runs half as fast as spindle of lathe, then for each revolution of work the rack will travel half length of pitch circle of 28 gear, which equals 2¾ inches, and lathe tool *H* should move in or out ¼ inch.

Suppose distance from *C* to *D* is 28 inches; then $2\frac{3}{4} - \frac{1}{4} = 2\frac{1}{2}$ inches, which is the difference of movement between *C* and *D*.

If there is a difference of movement of 2½ inches in 28, then $28 \div 2\frac{1}{2} = 1$ inch movement in 11⅕ inches, and ¼-inch movement in $(11\frac{1}{5}$ inches $\div 4) = 2\frac{4}{5}$ inches, which is the distance of *B* from *C*. This rig will cut screws within certain limits accurate enough for most purposes, as the variation of the arcs from straight lines tend to correct each other.

A conveniently graduated crossfeed hand-wheel is shown at *I*. Ring *K* turns freely on *I* and between *I* and ring *L*, which is fastened to *I* by screws. There is a binding screw *N* for holding *K* from turning when desired.

Ring *K* is graduated to read to thousandths on the work, and also to eighths, sixteenths, thirty-seconds and sixty-fourths, as shown in detail sketch.

In use, suppose we are turning a piece of work to .762 inch by micrometer caliper. A trial cut measures .794 inch; then turn ring *K* so that pointer *P* is opposite 94 on *K*, and tighten *N*, then

feed in until 62 is opposite pointer, and we have size with only one try. This is very convenient for cutting a number of screws all alike or a multiple threaded screw.

Work which has been hardened, such as reamers, drills, etc., can be tested to see how much it has sprung and whether it will clean up in the grinder, in this case remembering the graduations are thousandths in diameter.

The sixteenths, thirty-seconds, etc., are used in same way as the decimals.

The graduated tail spindle is nothing new, of course, but I have proved it to be such a great time-saver, if not work-saver, that I thought I would speak of it.

I screwed a pointer *Q* into the tail stock which projects out ⅛ inch or so and facilitates reading.

In chucking a hole, I feed the drill in until the lips of drill are flush with end of work, stop lathe, slacken tail stock, feed out spindle until pointer is opposite an even inch on graduations, tighten tail stock, and go ahead until proper depth is drilled. This is very useful for counterboring for screws, etc., using counterbore in chuck on spindle of lathe.

The best way to graduate spindle is to put between centers, gear lathe to 16 per inch, and turn tail spindle against a tool in tool post, then turn cone pulley around once, and mark again, and so on; of course, making some lines longer than others for inches, quarters, etc.

JAMES P. HAYES.

Meriden, Conn.

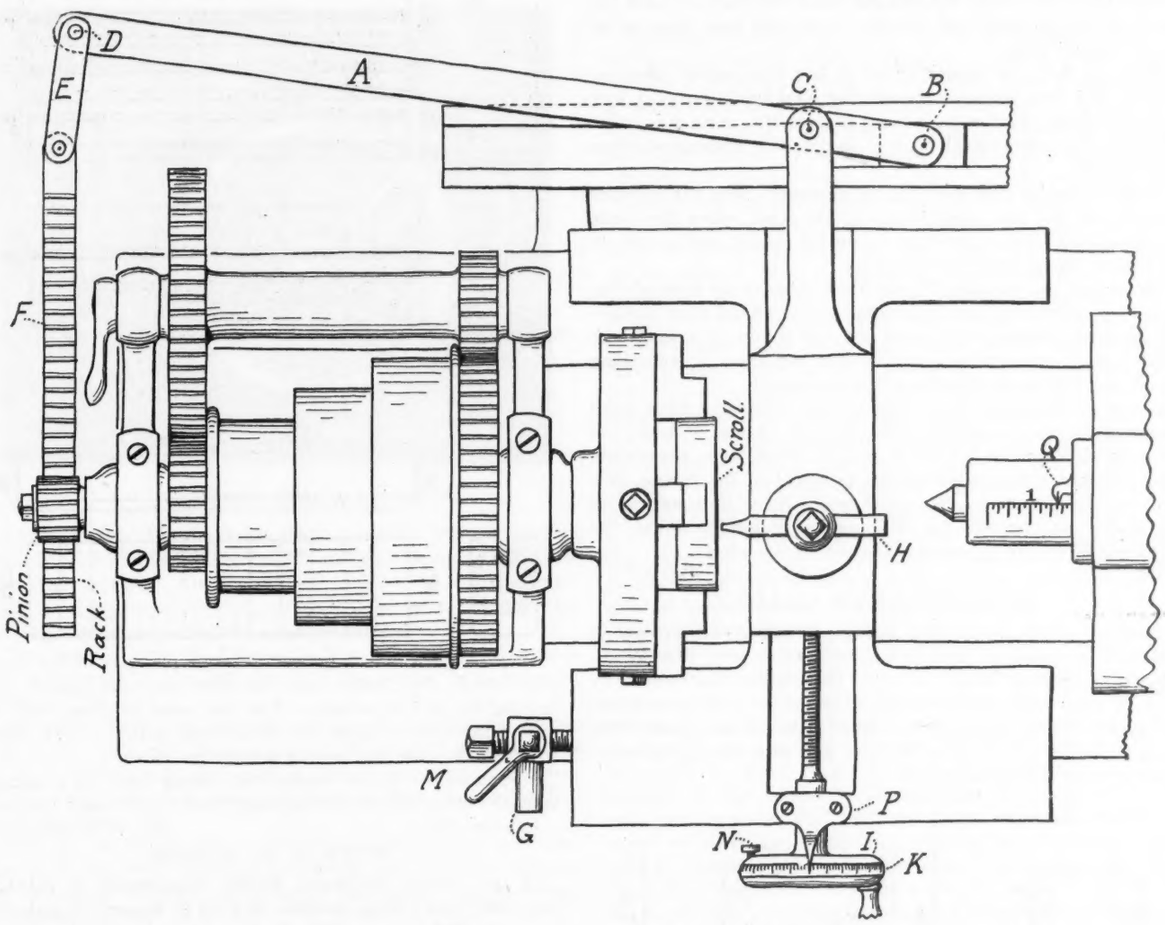
THE SUMMER SCHOOL AT CORNELL UNIVERSITY.

Why are you satisfied with hammer and oil can, when there are opportunities for you to advance a step higher, thereby enabling you to earn more money and earn it much easier?

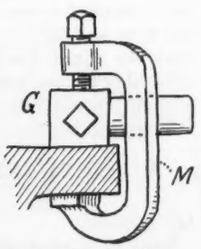
The Cornell Summer School is for machinists and engineers as well as for professional men. It is one of the best experimental schools in the country.

But the machinist and engineer says, "I cannot attend it; I am not well enough educated." Yes you are. If you can multiply, divide and subtract, you are all right. I will admit it is better for you to know a little about algebra, as letters are used to represent a formula, as I. P. H., which every engineer knows stands for indicated horse power.

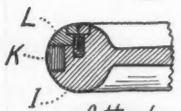
Again, you say, "What good will it do a mechanic?" I will tell you. First. If you are an engineer, you will learn how to find the freezing, burning or flashing points in oils. It will teach you to find the viscosity of oils, also to test oils for acids. Second, It will teach you to make an official test of a steam boiler and engine; you will know whether you are evaporating enough water per pound of coal; you will know how to test the steam for moisture; you will know the good and bad of an indicator card at a glance. Third. You will have an opportunity to make a test on a triple expansion condensing engine that is only using fourteen pounds of water per horse-power. Fourth. You will have experiments with condensers, air compressors, gas engines, hot-



Detail of Scroll.



Detail of Stop.



Attachment of Scale to Hand Wheel.

Detail of Graduations.

air engines, steam engines, air brakes, steam gauges, steam indicator spring, dynamometers, water motors, water meters, hydraulic rams, injectors, steam pumps, etc. Fifth. It will teach you how to test materials for the traverse, tensile, or compressive strength, and for impact, torsion, etc.

There is one test that every machinist and foundry man should know—that is Keep's test of cast-iron. It is a system that in time will be used by all first-class shops in the country. It teaches you to test iron for shrinkage as well as for strength, which is a very important factor in selecting good iron and testing new brands of iron.

There are other experiments that I have not time to mention. I name these, as I think of them and know that they are what the mechanic of the nineteenth century wants and must have or be in the second rank.

You say that you cannot afford it, but you cannot afford to miss it, and once you have the training, you would not part with it for anything. It elevates a man; it gives him more enjoyment when reading mechanical papers, as he can understand them much better.

I often wonder how men can be contented with the hammer and oil can and stop right there at that point, when they have brains and can just as well go on up the ladder and be able to earn more money and earn it easier.

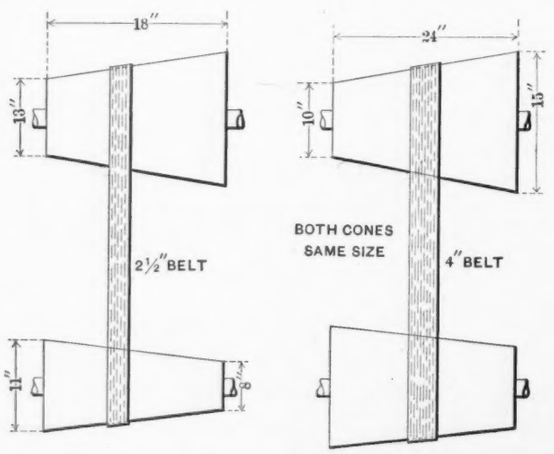
Some day you will be old, and then, when your strength begins to go, your employer looks upon you as an old stage horse—no good any longer; don't want you, but if you are a man with a head, your strength will last longer and there is something about you that is good and you are in demand.

I entered the shop when sixteen years of age. I have spent twenty years as a machinist and engineer. I was a student of the Cornell Summer School of '96 and speak from experience. Prof. George Berten Preston, the principal of the school, is a man who will spare no pains with you. He is thorough in all his work, and you will not only receive dollar for dollar, but hundreds of dollars for every cent spent at the school.

Ithaca, N. Y. MECHANIC.

CONE PULLEYS AGAIN.

Regarding the use of cone pulleys, to which we referred in the reply to question No. 65 in the March issue, Mr. W. C. Dennis, Worcester, Mass., writes: "These cones are extensively used in paper machines where the different parts of the machine are speeded to accommodate the other parts. I have made them from 18 inches face to 16 inches face, and with varying tapers of from 2 to 12 inches per foot."

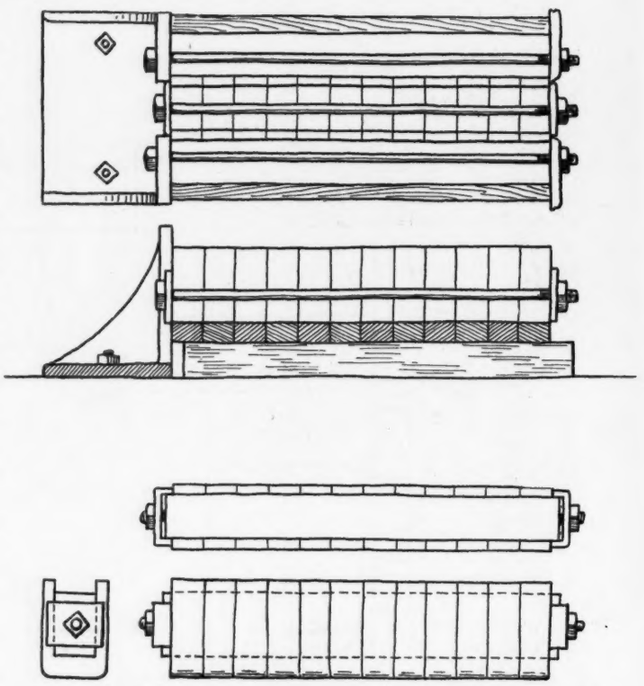


Mr. F. B. Coleman, Passaic, N. J., also writes: "We have used the pulleys for four years, and are now using them as you illustrated in Fig. 1. The small taper (Fig. 2) will not work."

We use the American leather link belt made by Chas. E. Schieren, Ferry and Cliff streets, New York City. One set of cones made of wood are of the sizes shown in the left-hand sketch, and the other of the sizes shown in the right-hand sketch. It is necessary to have a shipper at both cones to prevent the belt crawling to the high side. The shipping forks work on a threaded rod, and on each rod is a sprocket wheel. The two wheels are connected together by a long chain, and on one rod is another sprocket and chain which hangs down within reach of a man's hand. This chain can be pulled the same as you would a chain on a pair of falls. The shipping forks and rods are between the cones, and of course one fork is at the top of the belt and the other at the bottom to hold the belt as it comes on the pulley.

PLANING CONNECTING-ROD STRAPS.

The accompanying device is in use for planing twelve small connecting-rod straps at a time. After the straps have been planed parallel, they are lined up on two parallel strips and a bolt with a washer on each end is passed through to hold them rigid when moved.



They are then bolted against an angle plate, as in the sketch, after which the center bolt is taken out, the outside bolts holding the straps securely. The tool used to plane them out with consists of a holder for double-end cutters. Two cutters are used, the first just leaving a skim for finish.

The straps are finally finished by placing them on a mandrel, as in the lower sketch, and planing them to the right thickness.

London, Ont. C. A. MOREHOUSE.

WANTS TO KNOW.

In the "What Mechanics Think" department of February, page 188, I saw a shop problem by Fred E. Rogers. I make it to be a left-hand screw and the feed 1-42 of an inch. I took it to the shop and had a lot of fun with it, and most of the answers were like mine. I would like to have Mr. Rogers or some other subscriber tell me whether I am right, and give a simple rule for solving the example. J. B.

Paterson, N. J.

* * *

A CONTRAST—THE "MAINE" AND THE "MONITOR."

Mr. Editor:

Your very interesting and timely description of the engines of the Maine, which was accidentally (?) destroyed in Havana harbor in February 15th, calls to mind the engines of the first engineer's fighting machine, the "Monitor" of John Ericsson. Though this was a crude affair in many ways it contained the germ of the modern battleship, which is practically all engineering work, although the line officers get the credit while the engineers do the work.

The writer is not an old war-horse and has to take most of the data from hearsay, but a little personal examination of some of the monitors lying in the "back channel" of the League Island Navy Yard, at Philadelphia, proved most of it to be correct.

I do not remember which of the old boats it was I examined, down in the engine room and its turrets, but I think it was the Montauk, which is now being fitted for harbor defence, but it is difficult to see how they can be particularly effective against the battleships or armored cruisers which would oppose them.

The engine room of these old monitors is rather close quarters, to put it mildly, and there is much to interest any mechanic who has a taste for the historical and for the development of engineering in the navy.

When we consider that the hold was less than twelve feet deep and the draft not over eleven feet, it is evident that the engines to drive the screw must be of very compact form, and it becomes quite a problem as to driving the propeller shaft.

A general idea of the appearance of the engine can be had from the photograph, Fig. 1, although it is not particularly clear, as the light was decidedly poor and the flash light used did not give the best results.

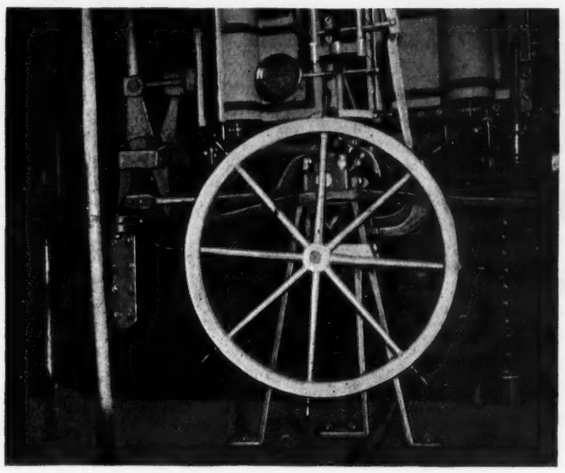


FIG. 1. ENGINES OF AN OLD MONITOR.

The large wheel in the foreground controlled the operation of the engines by adjusting the cut-off, and also changing the direction of the motion. But few of the details can be seen, although close observation shows the connections between the cylinders and the shaft, or at least part of them.

The engines were of Ericsson's double-trunk type, an idea being given by the rough sketch, made partly from memory, shown in Fig. 2.

As will be seen from the photograph, the engines lie rather high in the hold, which was necessary in order to get the screw as near the surface of the water as was desirable, and the center of the main shaft *d* was probably not more than four or five feet below the water line.

The cylinder was double, as will be seen, but was in one casting, as shown, with a division (containing an air space) between the cylinders. These were 36 inches in diameter, by 27 inches stroke each.

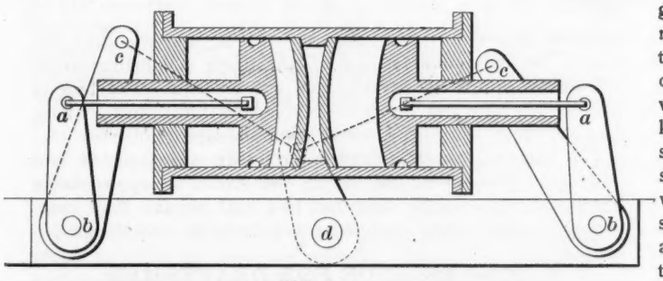


FIG. 2.

The sketch is crude and not correctly proportioned, but will give the idea fairly well. The trunk pistons connect with levers or cranks *a a*. These are connected with levers *c c* through the shafts *b b*, and connecting rods from *c c* to the main crank (shown dotted) drove the propeller at the end of shaft *d*. This is an ingenious transmission of power from reciprocating to rotary, and for compactness can be hardly be excelled, and although it does not represent modern practice, it should be remembered that this was designed and built over thirty years ago and under the exigencies of war, which required haste and immediate action, rather than theoretical design.

I have not shown any details in the cylinder construction, and merely wished to give the idea, but it must not be inferred that there were no stuffing boxes in the cylinder heads or that the pistons were solid. There were also air spaces in the cylinder heads. As I have never seen a photograph of the engine room of a monitor I have every reason to believe that this is the only one in existence at present, or it would probably have been shown among the collection of "war relics" which have lately made their appearance. Whether this is the only one or not, does not detract from its interest in the least, and I trust it will be considered worthy of a place in "Machinery." FRANK C. HUDSON.

Tombstone, Ariz.

* * *

TECHNICAL EDUCATION IN A LANCASHIRE TOWN.

The interest taken in technical training by progressive American machinists generally, must be taken as my reason for introducing the above subject. Bolton is one of the most prominent of a group of towns of which Manchester is the center and distributing agency. So far as I have been informed, (by persons acquainted with both places), it would appear to have a deal in common with the city of Providence, R. I., as it is a very important center of heavy engineering, (being one of the first English districts to take up the Corliss engine, first introduced by George Corliss, of Providence), and also having a very substantial, high-class cotton industry in all its branches. It has also about the same population as Providence. Great attention has been directed of late years to the subject of instruction bearing on the principles underlying the staple trades of the town. The Borough Technical School is the center of this instruction. No student is admitted who has not attended elementary classes in certain science subjects bearing on each trade dealt with. Several firms, of which the firm of Dobson & Barlow (well known in New England cotton circles), is most prominent, have scholarship schemes for the benefit of their young employés. Students can either attend day or evening courses. Through the courtesy of the authorities of the school I am enabled to forward the Editor full information regarding the work of the school, from which he will be at liberty to select such material as will, in his opinion, be helpful to, or of interest to his readers. JAMES VOSE.

Manchester, England.

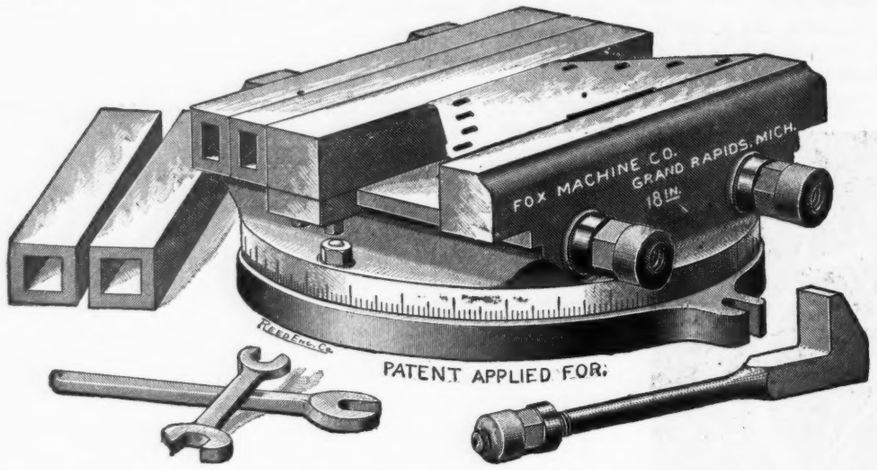
[The syllabus of the Bolton Technical School which Mr. Vose sends us shows the school to be very comprehensive in its scope, and we are sure that readers who are interested in technical education on this side will be glad to "compare notes" with efforts in this direction in Great Britain. We judge the school to be of about the same grade as the better class of mechanic art schools in this country. The circular shows views of well equipped carpenter and machine shops, and what is more unusual, views of large spinning, weaving and bleaching rooms with an extensive epuipment of machinery and apparatus. These latter departments are said to be among the finest of their kind in the world, and they must meet with the approval of every progressive person. The employés of the textile industry have for many years depended more upon "trade secrets" as their stock in trade than in any other line of business, and when the information concerning any industry is tied up in this manner it cannot be as well for either the employés or the industry itself as though the knowedge were disseminated to a greater extent. The scholarships offered by Dobson & Barlow are worthy of attention as showing the desire of one firm, at least, to assist their young workmen. Examinations are held in order to select the most suitable students to expend the money on. Elementary classes are provided at small cost to those who attend in order to prepare the young mechanics for these examinations. Which American firm will be the first to adopt a similar policy on a liberal basis? Editor.]

* * *

Moulding marble has been accomplished at McGill University, Montreal, where experiments have been carried out which show that marble under certain conditions may be moulded like clay. The marble is placed in sheaths of iron and submitted to long continued but gradual pressure. The marble shortens and expands laterally, and assumes a dead white color, the sparkling cleavage face of calcite being no longer visible. The experiments at McGill University were conducted with machinery whose counterpart does not exist elsewhere on the American continent, and prove that however brittle a rock may be, it is really a plastic substance capable of flowing into new shapes as surely as putty or dough.

A HEAVY PLANER VISE.

In this connection we illustrate an improved planer vise of large size made by the Fox Machine Co., Grand Rapids, Mich. Like several of the tools made by this company, this vise was first constructed for their own use and to supply a need felt in the manufacture of their trimmers. The tool is intended to supply the demand for a larger and more substantial vise for use on

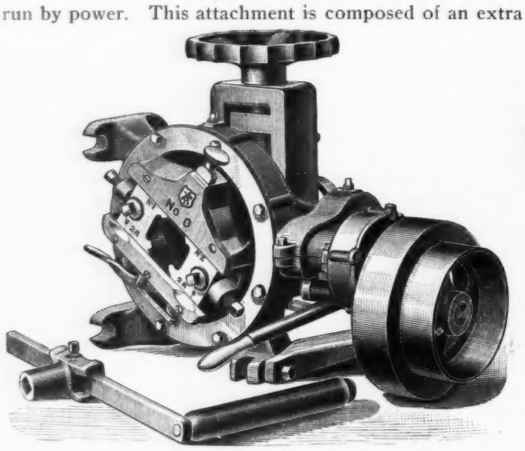


their shapers than could be found for sale on the market. The vise is made with the stationary jaw next the operator, and there is no opening in the bed in which dirt or chips might accumulate. The base is graduated and hollow parallels are provided for filling in back of the movable jaw. The capacity of the vise is 18 inches.

* * *

POWER PIPE-THREADING ATTACHMENT.

The Armstrong Manufacturing Company, Bridgeport Conn., have lately brought out an attachment which can easily be fitted to their new No. 0 hand pipe-threading machine, so that it can be run by power. This attachment is composed of an extra gear



and pinion *a* with cone pulley, which is slipped on the pinion of the second speed and has a stay bolted on the base to support it, making it perfectly strong.

The engraving shows the machine with attachment ready for the belt. The No. 0 machine is made for threading pipe ⅛-in. to 2-in., and bolts from ½-in. up to 1½-in.

* * *

PRACTICAL POINTS.

A thoroughly reliable belt dressing is a necessity in every well regulated factory, and probably no dressing is better known than Dixon's Belt Dressing and Leather Preservative.

As long ago as 1878 it was used on the big driving belt at the Paris Exposition, when every other means had failed to make the belt take hold of the pulley that was to start the thousands of feet of shafting and hundreds of machines. Those who use it claim that it prevents slipping and thoroughly preserves the life and elasticity of the belt.

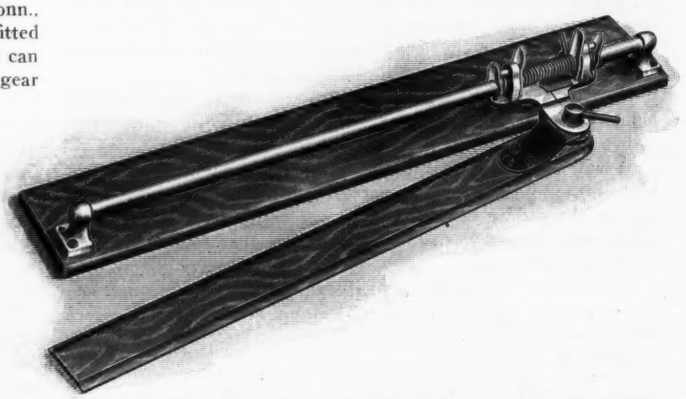
The Joseph Dixon Co. also send us a copy of the following letter from an official of the Pennsylvania Railroad:

"I had a gas engine at Sharon, Pa., running a pump, and the man that had charge of it allowed the lubricator to run dry and cut the piston, piston rings and cylinder. The makers of the gas engine said the cylinder would have to be sent to the shop and bored out and a new piston put in. I had some of Dixon's finely pulverized graphite, and I commenced to feed it into the cylinder through the suction pipe with the air and gas with immediate relief. After about two weeks the engine was running smoother and using less gas than ever before."

* * *

THE W. & T. SECTION LINER.

Messrs. George L. Warren and Edward J. Tessing, of New Haven, Conn., hav had patented a simple and practical section liner, which is so handy in its uses in the drawing room that it has met with great favor among draughtsmen and students who have tried it. It has a highly polished wooden ruler attached to a carrier by a steel plate and held rigidly by a lever screw. The carrier is fed on the rod, in either direction, by means of four binders; two at each end of the carrier, held in place by German silver springs. The spacing is regulated by a gauge, graduated into sixteenths, allowing accurate spaces to be made from ½-inch to 0. It is very easily adjusted and held firmly by a lever screw. The rod is supported by standards and mounted on a highly polished wooden base. The bottom of the base is provided with two small needle points to hold the instrument in place while in use; then the only



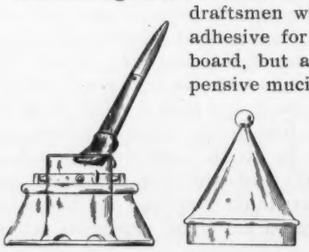
adjusting required is the gauge for spacing and the ruler for angles. So its simplicity, ease of adjustment and manipulation will readily appear to draughtsmen and students. The base is 12½ inches long and the ruler 11⅛ inches long, thus making the instrument capable of doing a fair-sized piece of work.

The carrier, standards and binders are silver plated and lacquered. The ruler plate, gauge and lever screws, are finely blued, and the wood hand-finished to a high polish. This combination makes a most handsome and desirable instrument.

* * *

A CONVENIENCE FOR DRAFTSMEN.

The mucilage bottle illustrated herewith will be appreciated by draftsmen who wish to use a high-grade adhesive for stretching the paper on the board, but are troubled with having expensive mucilage of this character dry up.



The design shown has a ground joint at the bottom of the cover. Moreover, provision is made for wiping the brush so as not to daub the mouth of the bottle and for keeping the brush handle away from the mouth when the cover is on. It is made by the Scattergood Co., 491 Philadelphia Bourse, Philadelphia.

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

86. J. W. H. writes: I am fitting up a small steam yacht and I would like to ask a few question regarding the machinery. 1. My boat is 35 feet long, 6 feet 6 inches beam; draught, 24 inches or 30 inches; good modeled boat. What size propeller would you advise to be the best for speed? I would not like to run engine above 250 or 300 revolutions per minute. Please state size and pitch. Boat to run on canal. Would a large wheel running slow answer? My engine is a 4 x 7 x 4½-inch compound steam pressure 190 pounds. 2. How many feet of 2-inch pipe will be required to condense the exhaust of above engine? 3. How should I run pipe outside of boat for keel condenser? 4. How should exhaust enter and where should vacuum pump take hold? 5. I would like to use water over and over. How can I make a separator to remove cylinder oil from water? 6. Should water be pumped through separater into tank from tank into boiler? 7. How can I make a jet blower to create draft in stack? 8. Can a noiseless blower be made? A. 1. Altogether the best plan for deciding upon the proper diameter and pitch of propeller is to observe the behavior of boats about like yours and find out the size and pitch of the propeller of one that behaves satisfactorily. Either that, or order one from some firm of much experience in fitting out small boats. Getting a wheel suitable for a small boat is often a matter of a good deal of experiment. If we were building such a boat we should order a wheel from some one of experience, giving them full particulars of boat and engine. If you insist on making your own wheel, you might try one 32 inches in diameter and 45 inches pitch. This will not give you very fast speed, but it probably will be all the wheel your engine will turn. If it will turn this wheel 300 revolutions, it will, however, give you more speed than you will want on the canal. 2. The length of pipe for a keel condenser is restricted to what will pass around the stern of the boat and return to the engine room. We should make the pipe 3 inches instead of 2 inches. 3. Run the pipe close to the boat, and low enough to be protected by the hull. 4. Let the exhaust enter one end of the pipe and connect the pump to the other end. 5. It is difficult to separate the oil from the water, and running in fresh water with a small boiler that cannot be reached for cleaning we should feed from the canal. Separating is generally attempted by passing the water through one or more vessels filled with filtering material. Sometimes this material is sand, sometimes charcoal; fine hay is highly recommended by some. 6. The air pump can deliver the water to the separator, it being allowed to flow by gravity to a tank from which it may be pumped to the boiler. 7. You can make such a blower by leading a small pipe, say three-quarters of an inch, from the boiler to the smoke pipe, turning it to look up, and screwing to the end a brass piece with a hole through it, tapering from three-quarters to three-eighths of an inch. 8. In no way that we know of.

87. J. E. H. writes: I would like to know of some practical way of tempering small, thin articles like corset springs and truss springs, to keep them in their proper shape; also how to keep them straight and true and have them hard enough for cutting tools. I have seen corset springs a foot long without a crook in them of very fine temper. They were evidently of foreign manufacture. A. We infer that you want to temper long, thin strips of steel either for springs or cutting tools, having them come from the tempering straight. Corset springs are generally low in temper, and could probably be straightened by rolling or otherwise after tempering. We do not know that they are, however. It will be very difficult, not to say impossible, to temper such long, thin strips of steel for cutting tools, keeping them straight. Even large files, which are comparatively thick, are, in tempering, partially cooled, then straightened and the cooling completed. Tempering them is a trade in itself. The novice would be certain of failure in the attempt. And files are not always straight, as you have doubtless observed. It might almost be said they are never straight. There is no way for you but to experiment, with every probability of spending a good deal of money in doing so. If we wanted such articles in small quantities we should order from some reputable spring maker. If you will experiment, you might try heating in a lead bath, kept at the right temperature, which temperature must be determined experimentally. Or you might heat in a sand or charcoal muffle—that is, in a vessel filled with sand or finely-broken charcoal and subjected to heat. Then there would be further experiment as to the way they should be dipped in the oil for cooling. If you want only a few such pieces, you might try hardening between two pieces of cast iron. Coat one surface of each piece with thick oil, heat the piece to be tempered, lay it on one of the pieces and cover it with the other piece till it is cold. If it comes out straight, you may possibly, by exercising great care, draw the temper, if necessary, without springing. The foregoing are hints as to how you might proceed in experimenting. Perhaps some of our readers who have had experience in tempering long, thin pieces can offer some suggestions.

88. R. G. writes: 1. I noticed in MACHINERY for March, the query in regard to the pressure exerted by a screw and wrench of given measurements. Please state in your next issue how to get the friction. 2. If a pair of 20 x 48-inch Corliss engines, condensing, running 60 revolutions per minute, giving 400 horsepower, were reduced to 45 revolutions per minute, and the speed of machinery reduced accordingly, how would it affect the coal bill, and what would be the percentage? 3. If the engines were reduced to 45 revolutions per minute and the speed of machinery kept to the speed attained by the 60 revolutions, how would that affect the coal bill and to what percentage? A. 1. There is no formula by which this friction can be calculated, and but few records of experiments. As intimated in the answer to which you refer, for nuts screwed tight it has been found to be as high as 70 per cent. It will, of course, depend upon the character and extent of the surfaces in contact, and can be found only by experiment. There is not sufficient data from which to formulate any rule. 2. You neglect to give the steam pressure, which it is quite essential to know. Assuming it to be about that commonly used for such engines, the load is about right as the engines are running. If you throw off 25 per cent. of the load by decreasing the speed of machinery to that extent, at the same time decreasing the speed of the engines 25 per cent., the relative work done in the cylinders will be the same as now, and at first thought it might appear that the saving in fuel would be 25 per cent. Such would not be the case, however, because the engines will not work so economically at the slower speed. The saving in fuel would probably be from 15 to 20 per cent., scarcely reaching the latter figure. 3. The engines would be overloaded at 45 revolutions, unless the steam pressure is more than 100 pounds. You might possibly contrive to run at a loss in fuel anywhere from 10 to 20 per cent. with a steam pressure of, say, 80 pounds.

89. H. D. writes: I would be glad to know the rule for finding the volume and temperature (Fahr.) of saturated steam when the pressure is known. A. The mathematical expression for the volume of saturated steam is

$$v = \frac{330.36}{p^{.941}}$$

This gives the volume of one pound of steam. In the expression v is the volume and p the pressure. The temperature is expressed by the formula

$$t = \frac{2938.16}{6\ 1993544 - \log.\ p} - 371.85$$

Here t is the temperature and p the pressure. We should not advise you to attempt any of these calculations. No one does. Probably for as little as 50 cents you can buy a book that has a table containing all the information you ask for. A book for this price is soon to be issued by "Locomotive Engineering," 256 Broadway, New York.

90. W. S. writes: A problem that has often presented itself to my mind and of which I have never arrived at any solution is the effect of a worn lead screw upon cutting a thread. Suppose

I wish to cut a screw 18 inches long, and we will call the lead screw 6 threads to the inch, for illustration. Suppose there are four points on the screw, *A*, *B*, *C* and *D*, and that from *A* to *B* the thread is good; from *B* to *C* it is badly worn; from *C* to *D* the thread is good. The nut closes down in good shape, on the good part of the screw. In cutting the thread the nut passes from *A* to *D*; now, what effect does the bad part of the lead screw have on the new thread, in relation to the pitch? A. In the first place, it is highly improbable that the thread is worn just as you have indicated, but granting it is so worn there is no practical way of solving the problem that troubles you except by actual trial. Cut a trial thread on any piece of iron of no consequence and accurately gauge the pitch at different points in its length. If we were to guess about it we should say that the nut would fall behind when it came to the worn part and jump ahead when it came to the good part of the screw.

91. W. R. writes: I can do the work required of an 18 x 24-inch throttling engine with 40 pounds steam pressure, but the superintendent insists upon my carrying 80 pounds and letting the governor throttle the pressure. It seems to me that this only gives the governor useless work to do and brings about no saving of fuel. The superintendent says it has been shown that it does result in a saving of fuel. Which is right, and why? A.

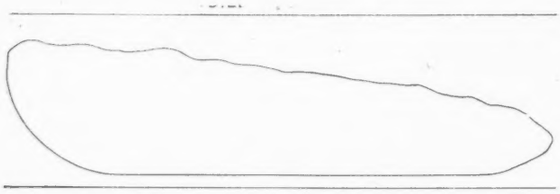


FIG. 1.

The superintendent is probably right. It is in the experience of most engineers that there is some gain in throttling, due to a slight superheating of the steam. The saving in your case will undoubtedly be largely controlled by the kind of governor you use and the weight of fly-wheel. With a light fly-wheel and a sensitive governor at 40 pounds pressure, you might expect to get some such indicator diagram from your cylinder as is sketched in Fig. 1, while with a governor not quite so sensi-

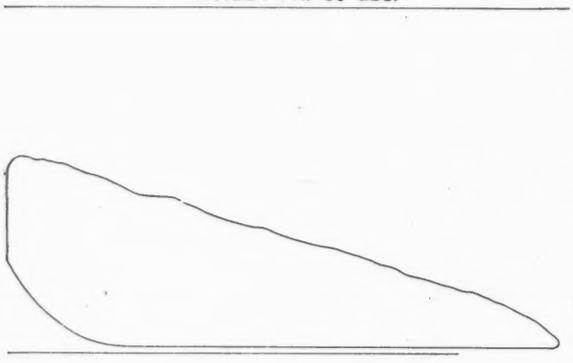


FIG. 2.

tive, perhaps, a heavy fly-wheel, and steam pressure 80 pounds, you might get a diagram similar to that represented in Fig. 2, The work done is supposed to be the same in both instances, but the terminal pressure, which is a measure of the steam used, is several pounds less in Fig. 2 than it is in Fig. 1. Then again, the greater gain, whatever that may be, from superheating by wiredrawing will slightly increase the economy of Fig. 2.

92. J. B. writes: I have a good deal of wrought iron to drill and use oil for lubricating the drill. The oil I use for this purpose is an expensive supply item. Is there anything I can satisfactorily use as a substitute? A. We do not know of any way by which quite so much wrought iron can be drilled with safety to the drills as by the use of plenty of oil. But, as you say, it is expensive, and when the drilling is such as can be done by cheap help, some substitute should generally be used. We have had as good success with the following as with anything: Dissolve in warm, soft water enough for the purpose ½ pound sal tartar, ½ pound refined borax, ½ pound carbonate ammonia, 10 pounds Babbitt's soap and 10 pounds sal soda. When all is dissolved add sufficient water to make from one to two barrels of the compound, according to strength desired.

93. C. W. R. asks: What is the best acid for marking tools? A. The best we know for the purpose is nitric acid. It should be diluted with water. Just how much water you should use, you can best find by experimenting on a piece of steel of no consequence, gradually adding more and more water, until the mixture behaves satisfactorily.

94 G. M. J. writes: 1. I have read somewhere that a flat drill, if ground to conform to an arc of a circle, will follow the center of work in a lathe, whether said work is cored true or not. As I have had no opportunity to try it I wish you would explain if it is true, and if so, why? 2. Is there not a misstatement in the March number, page 219, first column, 10-12 lines inclusive, in regard to the pitch? Would not an increased pitch produce a smaller cross-section of flute and a decreased twist instead of an "increase twist," as stated in the article? A. 1. A drill ground as you indicate will not act as you say you have read it will, unless it is used like an ordinary flat chucking drill, where the drill is supported by a rest and held firmly in position by a wrench, so that only one edge will cut when the hole runs out of center. The hole will then be larger than the drill, of course. 2. Possibly the author's use of terms is not quite so clear as it might have been. We think, however, that by reading a few lines before and after those mentioned his meaning is made quite apparent. We do not understand the other question which you send. Please send a little sketch with more full explanation.

95. J. T. D. asks: How can I make a casehardening liquid such as I have seen, and how is it used for casehardening small articles? A. There are various ways, undoubtedly, of making and using such a liquid. One way of making and using such a liquid, perhaps as good as any, is to procure a plumbago crucible large enough to serve your purpose and make a wire basket with a handle so that you can readily lower it into the crucible and quickly remove it. Set the crucible over a smith's fire and fill it two-thirds full of a mixture of half salt and half prussiate of potash. Heat slowly till fusion is complete and the mixture is hot enough to heat the pieces cherry red. Put the pieces in the basket and lower the basket into the crucible, letting it remain there five to fifteen minutes, according to the depth of the hardening desired. Quickly remove the basket and empty the contents into a deep trough of pure, cold water.

96. J. A. B. writes: In tempering a drill for drilling steel that has not been annealed is it advisable to use potash? A. There are various recipes for tempering drills for hard material such as you mention. In our experience there is nothing quite so good as pure cold water; that is, if the drill is made from the best tool steel, which it should be. In drawing the temper let it run down very slowly, endeavoring, as nearly as may be, to leave just enough heat in the drill when cooling it to bring the temper right.

* * *

FRESH FROM THE PRESS.

A COURSE IN MECHANICAL DRAWING, by John S. Reid, Instructor in Mechanical Drawing and Designing, Sibley College, Cornell University, Ithaca, N. Y. Published by John Wiley & Sons, New York. 128 8vo pages, illustrated. Price, $2.

This work is divided into five chapters, devoted respectively to Intruments and their Use, Geometrical Drawing, Conventions, Lettering and Orthographic Projection. One feature of the work will undoubtedly commend itself to practical instructors of drawing. The book is intended for students who propose to take up mechanical and electrical engineering, and only enough of projections and descriptive geometry is given to enable a student to solve the problems that arise in these branches of engineering. Should a student desire to study architecture, for example, a more extended knowledge of these subjects would be necessary; but that is no reason why students in engineering should be compelled to devote their time to an extended study of the subject when they would doubtless prefer to spend it upon some branch more directly in their line.

The chapter upon geometrical drawing takes up all the geometrical problems that a draftsman is likely to meet with, and in the figures one very excellent method is adopted, which, though simple, we do not remember to have seen before; that is, wherever an arc of a circle is described a radius line is drawn from the center with an arrow point on the end touching the arc, which shows at a glance what center is taken and what arc is drawn from that center, without having to follow through all the description in detail.

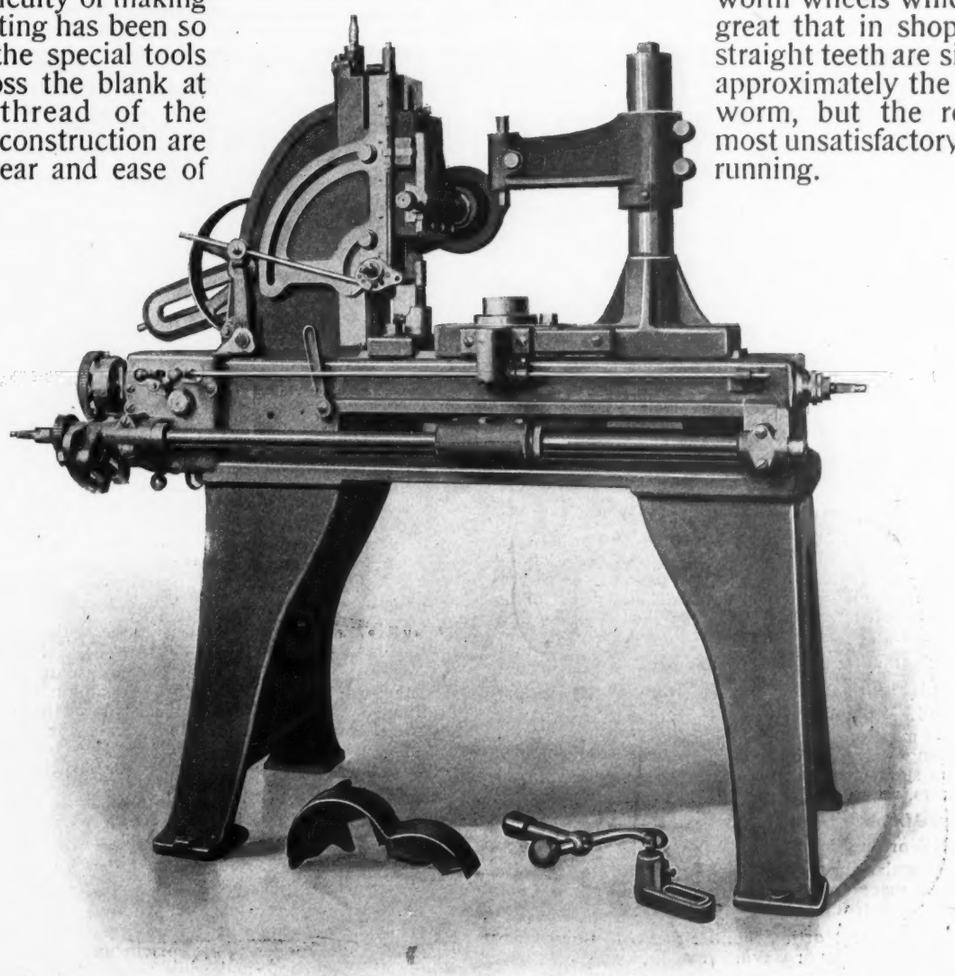
The chapter upon conventions falls short of what one would naturally expect to find in a chapter under this heading. It shows in

Double Service at the Same Cost

is obtained in

The Whiton Gear Cutter.

HOBBING worm wheels has always been an operation that required a special machine, otherwise it could be done only with considerable difficulty. It has generally been necessary to first nick the blank and then fit up the milling machine especially for the operation, the whole taking an amount of time that is entirely out of proportion to other pieces of work requiring a like amount of stock to be removed. The difficulty of making worm wheels which are close-fitting has been so great that in shops not having the special tools straight teeth are simply cut across the blank at approximately the angle of the thread of the worm, but the results by this construction are most unsatisfactory both as to wear and ease of running.



The Whiton Automatic Gear Cutter is fitted especially for hobbing worm wheels without nicking the blanks. It is as easy to make a theoretically correct worm wheel on this gear cutter as it is to cut the teeth of an ordinary spur gear. This is one of the important features of the machine which make it an all-around shop tool, designed for all classes of gear cutting, and the whole machine complete costs no more than an ordinary gear cutter which is capable of turning out no more than half the work and a much smaller variety.

Full particulars furnished by the manufacturers,

THE D. E. WHITON MACHINE COMPANY,

No. 54 Howard Street, New London, Conn., U. S. A.

detail how to make cross sections of all the engineering materials, including different kinds of stone, rock, wood, earth, etc., but no mention is made of the fact that it is coming to be the practice in mechanical drawing to make all sections alike, and wherever there is doubt to state what the material is. Occasionally a mechanical draftsman has to make drawings of buildings or masonry constructions involving sections of materials that he does not ordinarily use, in which cases this chapter will prove very useful The only other subjects mentioned under the heading are conventional lines, breaks, cross-sections of pulleys and conventional screw threads. It does not tell how to place dimensions on a drawing, how to represent bolt heads, or place the dimensions on bolts, how to represent boiler joints, sections cutting through pieces bolted together, invisible cross-sections, nor how to place the dimensions on a row of holes in a circle. In fact, it seems to us that most of the conventions that a young student wishes to know about are omitted, and those he wishes to know the least are given prominence.

The chapter on lettering will be very useful, because it tells exactly how to construct Roman and Gothic letters. A great deal might be written upon lettering which might help a student, but as two or three excellent books upon this subject have recently appeared, the author wisely refers the student to these without attempting to devote a large amount of space to the subject, such as would be necessary if he covered it completely.

Under projections the author describes both the first and the third angle methods, which makes the student familiar with both, but he recommends that the third angle be used, which we believe to be in accord with the almost universal drawing room practice.

ADVERTISING LITERATURE.

THE STANDARD SIZES FOR CATALOGS ARE 9 x 12, 6x9 AND 3½x6 INCHES. THE 6x9 IS RECOMMENDED, AS THIS SIZE IS MOST LIKELY TO BE PRESERVED.

WELLS, BROS. & CO., Greenfield, Mass., catalog of screw-cutting tools and machinery. 127 pages, pocket size.

The well-known line of taps, dies, screw-plates, bolt-cutters, blacksmith's drills and other tools are fully described, with illustrations and price-lists.

THE BIGNALL & KEELER MANUFACTURING CO., Edwardsville, Ill. Catalog No. 24 of Pipe Threading and Cutting Machines. 108 pages, pocket size.

Besides illustrating and describing the tools made by this company, this catalog contains 20 pages of tables and useful information for pipe fitters and engineers, and a large number of testimonials.

GOODELL BROTHERS COMPANY, Greenfield, Mass. Catalog No. 3 of Mechanics' Tools and Specialties. 56 pages, 6 x 9.

The tools illustrated include the Goodell automatic, interchangeable screw-drivers and drills, which operate by simply pushing the handle; hollow handle tool sets, hand drills, breast drills, bench drills, polishing heads and a number of other tools useful to mechanics.

THE FOSTER ENGINEERING COMPANY, Newark, N. J. Catalog of Specialties and Fittings for the use of Steam, Water, Gas, or Air. 64 pages, 6⅛ x 9¼ inches.

The specialties mentioned include the Foster Pressure Regulator and Reducing Valve, which is made in sizes from 1 inch to 18 inches; pump speed-governors, pump regulators, stop valves, damper regulators, relief valves, etc.

THE POORMAN MANUFACTURING COMPANY, Piqua, O. Catalog of Sheet Metal Working Machinery. 20 pages, 7½ x 10½.

In addition to regular sheet metal working machinery this company make special machinery for manufacturing corrugated conductor pipe and eaves trough.

JAMES T. MACKAY, 712 North Second street, St. Louis, Mo., dealer in standard and labor saving machinery, sends us a copy of his first catalog. It contains 64 pages, and lists such tools as are generally carried by a supply house selling metal workers' machinery.

FRICTION AND LUBRICATION is the title of an eight-page circular issued by the Joseph Dixon Crucible Company, Jersey City, N. J., and containing information upon this subject.

THE ILLINOIS STEEL COMPANY, Chicago, Ill., has issued a handsomely printed pamphlet containing a description of their works having about thirty full-page illustrations of different departments of the plant.

HOLDEN & BROOKE, Sirius Works, West Gorton, Manchester, England, have sent us a catalog of the "Sirius" Patent Self-Acting Injector for live steam. It is fully illustrated, shows the details of different types of the injector and describes the methods of attaching them.

THE REED MANUFACTURING COMPANY, Erie, Pa., are issuing a vest-pocket kinetoscope. It consists of a little book on the different pages of which are the successive positions that would be taken by a Reed Pipe Wrench, and the hand which operated it. By turning the pages rapidly, the wrench appears to move back and forth, as though in motion.

THE SPRAGUE ELECTRIC COMPANY, 20 Broad street, New York, send us two catalogs, both of which are interesting from an artistic as well as from a mechanical standpoint. One describes and illustrates the Lundell Motors as applied to the independent driving of printing presses, and the other describes the 1898 models of the Lundell Fan Motors.

NEW YORK STANDARD WATCH COMPANY, 11 John street, New York. Catalog of the Standard Electric Clocks. The clocks described are for office, factory and jewelers' use, and are operated by dry-cell batteries. They require no winding.

THE UNIVERSITY OF VERMONT, Burlington, Vt., have issued a special bulletin of the engineering department of that institution, giving views of the buildings, laboratories, and other departments, and information for intending students.

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MANUFACTURERS' NOTES.

THE FORMER DAVIS & EGAN MACHINE TOOL COMPANY, is now known as the American Tool Works Company. The change of name goes with a reorganization of the concern, and which includes an increase of the capital stock from $500,000 to $1,000,000. The steadily increasing foreign business of the company has necessitated its enlargement, and the change of name is made in the interest of this same foreign business.

The new charter is secured in West Virginia. The capital invested in the Davis & Egan Company forms the common stock of the American Tool Works Company, and remains in the same hands. Of the $500,000 new stock all is preferred. Of this amount only $200,000 will be put out at this time, the remainder being held in the treasury. Mr. Chas. Davis remains president of the new company and the same line of business will be conducted as before. In addition to the active work of agents now going on abroad, and as rapidly as the additional works can be installed in Covington, additional men will be put to work.

THE CORRESPONDENCE SCHOOL OF TECHNOLOGY, of Cleveland, O., has lately been incorporated with the Institute for Home Study of Engineering, also of Cleveland. Prof. E. P. Roberts, of the Correspondence School of Technology is technical director; F. D. Leslie, business director, and J. H. Norton, secretary and treasurer of the Institute under the new management. The school is now partially under control of an advisory board not financially interested.

The catalog recently issued states that the Institute is for those who find attendance at a school for resident students impossible or impracticable and does not lay any claim to equality with personal attendance institutions. It advises all to attend a regular college if possible. It is designed to lead men of limited opportunities to higher ground and to impart to them a knowledge of engineering that will be of every day use. It is also designed to give graduates of technical schools who have become "rusty" a helpful review. For these men a course in advanced mathematics is provided.

THE SPRAGUE ELECTRIC COMPANY are meeting with considerable success in placing their Lundell Horseless Carriage Motor on the market. Quite a number are in use in this country and abroad, particularly in England. In London, the Lundell Motor Equipment has recently been placed upon the mail van service, and excellent results are reorted. Since the vans have been so equipped it is stated that none has ever been behind time—a record which no other vehicle ever succeeded in obtaining.

HEBER WELLS, of this city, who deals in Pattern Letters for castings, etc., writes us that he has just added to his stock a new style, called the "Deep Block." It is on the Gothic order, but thick. As it has fine lines it is well adapted to tablets and other purposes.

THE NEW BIRDSALL COMPANY, Auburn, N. Y., are making arrangements for obtaining some improved machine tools for machine shop, boiler shop, blacksmith shop, foundry, wood shop and paint shop, and while they are not yet ready to purchase would like catalogs of manufacturers.

W. S. ROGERS, who was formerly the superintendent and mechanical engineer of the American Laundry Machine Company, Cincinnati, O., has become the treasurer and general manager of the Ball Bearing Company, Watson street, Boston, Mass. We understand that he is still to retain an interest in the lately formed Rogers Laundry Machine Company, of this city.

WANTED BY MANUFACTURER.—Experienced smith-shop foreman familiar with oil furnaces, light and heavy forging; suitable for pumping engine and mining work. Write, stating age, experience and wages. References required.
Address "A. K.," this office.

WANTED.—Complete copies of MACHINERY, Vol. I.
Address, stating price, "A. B.," care of this office.

SMALL STEAM ENGINES AND BOILERS.—Castings $2.00 up. Also castings for water motors, gas engines and locomotives. Circulars free. GRANT R. SIPP, Paterson, N. J.